ECOLOGY AND HABITAT ANALYSIS OF JERDON'S COURSER (*Cursorius bitorquatus*) AND CONSERVATION MEASURES IN SRI LANKAMALLESWARAM WILDLIFE SANCTUARY

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By

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This is to certify that the thesis entitled **ECOLOGY AND HABITAT ANALYSIS OF JERDON'S COURSER (*Cursorius bitorquatus*) AND CONSERVATION MEASURES IN SRI LANKAMALLESWARAM WILDLIFE SANCTUARY** submitted by **Mr. SHAIK AMEER BASHA, M.Sc.**, to Sri Venkateswara University for the award of Degree of **Doctor of Philosophy in Zoology** is a bonafied research work carried out by him under my supervision. The results contained in this thesis have not been submitted in part or full to any other university or institute for the award of any degree, diploma, associateship, fellowship or other similar titles

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DECLARATION

I declare that this thesis entitled **ECOLOGY AND HABITAT ANALYSIS OF JERDON'S COURSER (*Cursorius bitorquatus*) AND CONSERVATION MEASURES IN SRI LANKAMALLESWARAM WILDLIFE SANCTUARY** is entirely original and has not been submitted to any other University or Institution for the award of any degree or diploma.

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DATE: 31-1-2002

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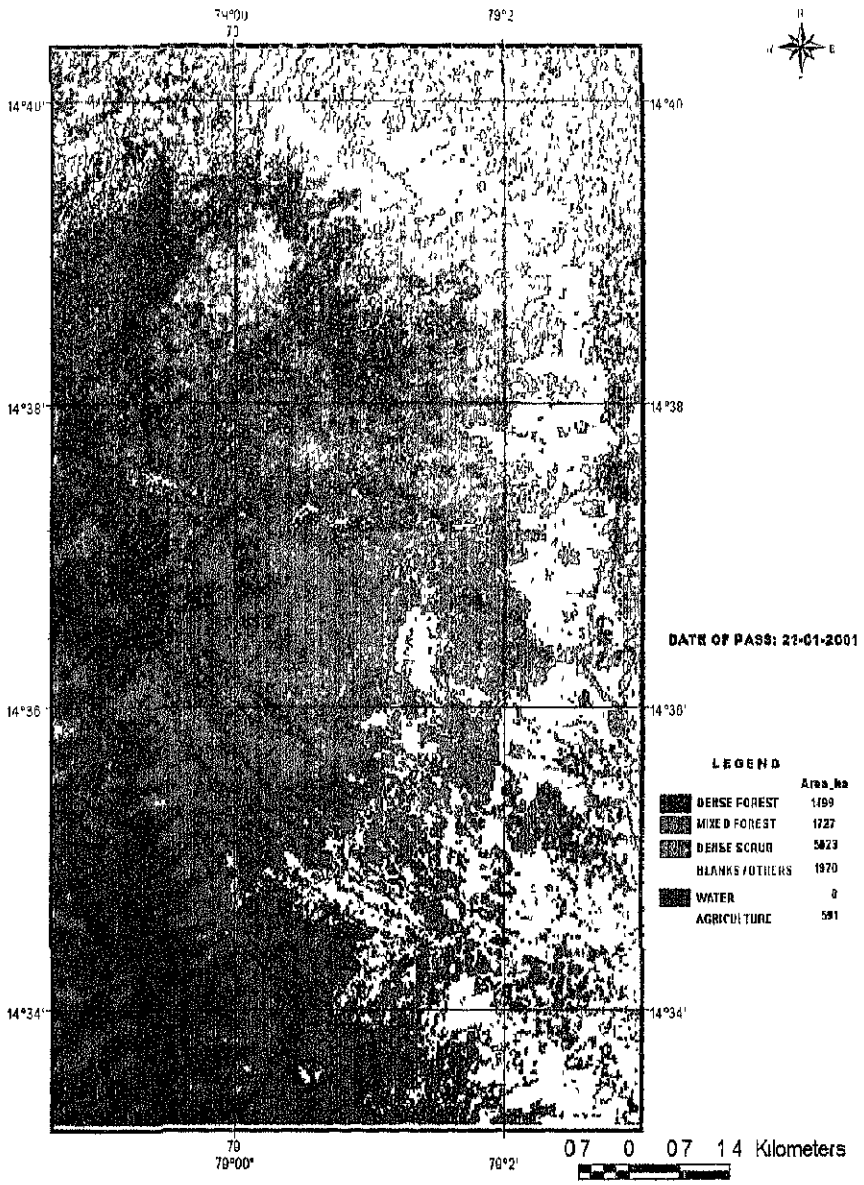
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PREFACE

Jerdon's Courser (*Cursorius bitorquatus*) also known as Double-banded Courser, derives its name after Dr T.C. Jerdon, an army surgeon of Nellore town who first spotted it in 1848 and recorded it from the hilly areas above the Eastern Ghats of Nellore and in Cuddapah District of present Andhra Pradesh, India (Jerdon, 1877) For over 80 years,this nocturnal bird was presumed extinct and several surveys to rediscover it by researchers of BNHS and Smithsonian Institute proved futile. It was in 1986, the bird was rediscovered by Bharath Bhushan of BNHS with the help of Athanna, a local resident (IUCN Bulletin 1986, Bhushan 1990). **Wildlife conservationists and enthusiasts in Andhra Pradesh State were excited when Jerdon's Courser was spotted in Sri Lankamalleswaram Forest Area, a bird almost written off as extinct (Tikader, 1983) as it was last seen in 1900 by Howard Campbell in the Pennar River valley. The famous Ornithologist of India, Dr. Salim Ali's visit on January 12, 1986 to see the bird for the first time which was caught to show Dr. Salim Ali by a local resident of Reddipalli, Mr. Ithanna (IUCN Bulletin, 1986, Bhushan, 1990). Dr. Salim Ali visited in his advanced age of his 80's to see the prize catch for himself, but the bird was dead by the time he arrived.** Conservationists all over the World turned their attention on the **"Great lost & Found Bird".**

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Introduction

Indian wildlife possesses a rich and diverse fauna in its different ecosystems. India's avifauna ranks among the World's ten most diverse and unique, representing 14% of the World's total avifauna (Subramanian, 2001). There were good historical accounts on Ornithology in India since the beginning of the nineteenth century Dr T. C. Jerdon, Brain Hodgson and Edward Blyth were earliest founders of Indian Ornithology (Ali and Ripley, 1969). **There are about 10 ground nesting birds in Sri Lankamalleswaram Wildlife Sanctuary, of which Jerdon's Courser is rated as the most endangered species on the verge of extinction confined to this sanctuary and the present investigation attempts to understand ecological aspects of Jerdon's Courser.**

Jerdon's Courser (*Cursorius bitorquatus*), commonly called as "Double-banded Courser", is a poorly known bird. The name, Jerdon's Courser, is after Dr. T. C. Jerdon, an Army surgeon from Nellore Town who first spotted the bird in 1848 from the Pennar river valley above the Eastern Ghats of Nellore and Cuddapah Districts of the present Andhra Pradesh State, India (Jerdon, 1877).

Materials and Methods

STUDY AREA

The present study was carried out in Sri Lankamalleswaram wildlife sanctuary located in Cuddapah district of Andhra Pradesh, India This wildlife sanctuary covered area of 465 sq. km. It includes 12 forest beats and the topography is hilly to gently scrub, climate is dry and temperature is between 18^0 c to 39^0 c.

The forests in the sanctuary vary from deciduous red sander forest on the hill to scrub area in the plains. The study area is the scrub area where Jerdon's Courser bird is usually spotted. The plant species in the scrub where the Jerden's Courser is recorded, includes *Carissa carandas, Dodonea viscosa, Maytenus emerginata, Diospyros chloroxylon, Hardwickia binata, Torenia asiatica, Zizyphus xylopyrus and Acacia latronum.* Among the birds, Jerdon's Courser, Common Courser, Nightjars, Stone Curlew, Grey Francolin are commonly sighted.

Chapter - I

JERDON'S COURSER'S (*Cursorius bitorquatus*) HABITAT ANALYSIS AND ECOLOGICAL EVALUATION IN SRI LANKAMALLESWARAM WILDLIFE SANCTUARY.

I BIRD SIGHTINGS

II PLANT COVERAGE

III FRUIT BEARING TREES

IV FOOD COVERAGE: ANALYSIS OF EXCRETA

V. PREDATORS

VI. HABITAT SHARING ANIMALS

VII WATER RESOURCES

VIII SOIL ANALYSIS

IX. HABITAT DESTRUCTION AND ANTHROPOGENIC ACTIVITY.

Chapter

Classification of Jerdon's Courser *Cursorius bitorquatus (Blyth)*

Class	:	Aves
Order	:	Charadriiformes
Family	:	Glareolidea
Sub family	:	Cursoriinae
Genus	:	*Cursorius*
Species	:	*bitorquatus*
Authority	:	Blyth (1848)

I. BIRD SIGHTINGS

Jerdon's Courser birds were searched in Sri Lankamalleswaram Wildlife Sanctuary from 8 P.M. to morning 4 A.M. twice in a month and for three years. The number of birds spotted are given in Table-1 (a, b, c, d, e, f).

Bird Sightings

Sri Lankamalleswaram Wildlife Sanctuary seems to be the only restricted area where Jerdon's Courser birds are found and no where else in the World (see Introduction) The sanctuary has an extent of 465 sq km area but the birds are not seen in all locations of the sanctuary. The birds are found frequently in the night for feeding and other activities in the certain areas or locations of the sanctuary These area names in local language is given in Table-1(a, b, c, e) and the sightings are noted from 1998 July to 2001 June. The birds were not observed in other areas of the sanctuary. The possible reasons for non sighting of these birds in other areas are discussed later in this chapter

From Table-1 (a, b, c) it might be seen that more birds were encountered in the Medaravani Kunta barakalu followed by Veera Reddy Chaelaka, Ragikayala Kunta Badava and Dhaggoni Chaelaka. It may be noted, with caution, that these numbers were calculated for the core area of the 465 sq. km area covering 12 sq km (Table-1d). The observed number in the rest of the area of sanctuary excluding the degraded habitat area based on direct observational study is also given in Table-1(e & f). A marginal increase in bird number in the 3rd year might not be due to population increase.

Problems in Sighting

The birds can be sighted only in the night and most of the time after 9 PM It is very difficult to sight the bird as the bird has to be located from 30 to 40 meters distance by focusing powerful torch light and after identifying the exact bird (differentiating from Common Courser), one has to approach with least noise, unmindful of thorny bushes and rough terrain laden with pebbles and mindful of likely poisonous reptiles For this reason the search party divided itself in to 4 batches cover different localities. The birds in other areas are expected numbers and the areas mentioned in Table-1 (a, b, c, d, e, f) are direct observed numbers. The Jerdon's Courser birds are thus highly endangered and restricted and hence the found bird numbers are very few. The bird sighting were done from 1998 to 2001 for every month The birds were rarely found in other areas excepting the degraded areas under sub chapter "Habitat destruction and anthropogenic activity" of this chapter. Hence the reasons for sparse distribution of Jerdon's Courser in Sri Lankamalleswara Wildlife Sanctuary is based on the observations made on suitable habitat of Jerdon's Courser (chapter II) based on both satellite remote sensing and ground truthing in other words the direct observational studies The habitat are also identified during night by demarking the excreta of Jerdon's Courser and observing habitat during its absence in day time (Table-2)

II. PLANT COVERAGE

The plant coverage for habitat area of Jerdon's Courser is presented in Table-3 The plant coverage includes the usual plants which are found around and near the open grounds of Sri Lankamalleswaram Wildlife Sanctuary, where the birds are sighted. Six locations were analysed at random for plant composition. The mean plant composition is given in Table-3 The habitat description is given in Table-13 An adjoining water stream namely "Pillavanka", the width of the stream is 5-6 mts and runs for a long distance from mountain to plain area passing through the habitat of Jerdon's Courser In all the locations there were more number of *Carissa carandas* fruit bearing trees infected with termite colony on the bark (Fig 13) The number of plants found in the order of highest to lowest number are.

Dodonea viscosa > *Carissa carandas* > *Maytenus emerginata* > *Acacia latronum* > *Diospyros chloroxylon* > *Zizyphus xylophyros* > *Diospyros ferrea* > *Soymida febrifuga* > *Hardwickia binata*

The above plant coverage reveals that Jerdon's Courser's habitat area comprises mostly *Carissa carandas* (kalivi), *Maytenus emerginata* (Danti), *Dodonia viscosa* (Bandaru) The analysis reveals that it is a shrub and a scrub jungle with least number of tall trees There are a few shrub trees which show height up to 15-25 feet near the "Pillavanka" stream. The analysis of plant coverage is very important because of the following reasons

1 The plant cover helps in offering protection

2 The plants offers food either directly or indirectly, for example *Carissa carandas* (Kalivi) ripen fruits, when fall on the ground are direct food for Jerdon's Courser. The termites, which are attracted by *Carissa carandas* bark as well as other plants, the dead wood which falls on the ground attracting termites are indirect sources of food from support system of plants. The plants such as *Dodonia viscosa* (Bandaru), *Maytenus emerginata* (Danti), *Diospyros chloroxylon* (Ulindra) are bushy in nature with branches stooping down the surface (Fig 4) trees offering protection and shade unlike *Carissa carandas* which is an erect, thorny and fruit bearing tree. Thus the Jerdon's Courser's habitat plant support system are *Maytenus emerginata* (Danti), *Diospyros chloroxylon* (Ullindra), *Dodonea viscosa* (Bandaru) for protection and *Carissa carandas*, whose dead wood infested by termites and ants are the food for bird offered indirectly and directly by plant support system. The entire scrub jungle or shrub jungle is highly open type and placed apart enclosing a number of open grounds, which are habitat areas of Jerdons's Courser. The Lux value in the open area is 725 X 100 and the Lux value under the bush of *Diospyros chloroxylon* + *Maytenus emerginata* is 28 x 100 at 9 A.M. The percent Lux value in the bush area is 9.4% of open area.

Importance of vegetation Coverage: Corroboratory evidences

The most important biological parameter of a habitat is the vegetation, which is inseparable from animal communities because of the fact that both plant and animals have evolved together and trees provide resources and habitat structure for almost all other species (Cannon *et al.*, 1998) Vegetation is important in a habitat since it has both food as well as cover value. Hence animals respond to changes in vegetation.

Vegetation plays a major role in cover construction of wildlife animals particularly for wild avifauna. Cover, which affords protection to animals from weather, predators by offering a better vantage point (Shaw, 1985). Vegetation provide 'Refuge cover' to ground nesting birds. Gopal (1992), reported that if the vegetation is fragmented by many reasons the jungle fowl can be easily hunted by Shikaris. Bird species often seek refuge, feed and nest only in certain vegetation strata (Gutzwiller *et al.*, 1998) and each species used a specific macro-habitat for foraging (Fasola and Biddau, 1997)

Ali and Ripley (1969), Grimmett *et al.*, (1999), reported that ground nesting birds such as coursers, curlews, lapwings, grouse and doves usually prefers scrub jungle habitat as its refuge cover. For example, Cream-coloured courser affects spares scrub jungle with *Salsola* and *Sueda* bushes or dotted with *Capparis* bushes (Sharma, 1992). Lapwings and curlews prefers thorny scrub vegetation on stony ground. The Sand Grouse affects thinly scrubbed

plains with xerophytic vegetation. Doves prefers open mixed deciduous and bamboo forest For example, the Indian Ring Dove affects open dry deciduous forest with *Acacia* and Butea trees, the Indian Red Turtle Dove affects open scrub jungle particularly where interspersed with *Euphorbia* hedges and *Opuntia* thickets, pigeons affects broad leaved hill forest with Oak, Elm, Older, Ficus trees. Karter (1997) reported that Amazonian birds always prefers bamboo habitats, hence these birds are called as 'bamboo specialists'. Lemay *et al.,* (1998), reported that during the nesting and breeding periods Spur Grouse chiefly used shrub layer. These studies clearly indicates that the significance of vegetation in roosting cover as well as foraging cover of avifauna

Vegetation cover of the habitat provide food for animals, which inhabited in the habitat. The main vegetarian food of the ground nesting birds is seeds of grass and weeds belongs to the different species like *Cyamopsis psoralioides, Eleusine arista, Pseudanthipteria hispida* etc (Meinertzahargen, 1954; Ali and Ripley, 1969., Grimmett *et al.,* 1999), a variety of berries and drupes (Gould and Rutgers, 1969., Majumdar, 1984).

Vegetation cover of the habitat provide breeding cover for many species of ground birds. Some birds prefers a specific habitat of vegetation strata as breeding cover. For example, Jungle Fowl breeds under a bamboo bush. Partridge live only on the ground but prefers low bushes for breeding cover. Floricans place their nest on ground with grass The breeding cover of the Pigeons and Doves are extremely of a leafy branch.

Many bird species survive in specialized habitats and depends on the vegetation cover for breeding, roosting, feeding and foraging (Fasola *et al.*, 1997 , Gutzwiller *et al.*, 1998) If these habitats are destroyed and fragmented the threat of extinction looms

III. FRUIT BEARING TREES

Carissa carandas (Kalivi), *Diospyros chloroxylon* (Ulindra) and *Diospyros ferra* (Ooty) are the fruit bearing trees When these fruits ripen and fall on the ground, they might form the food for Jerdon's Courser. The analysis of excreta during fruiting season of *Carissa carandas* (August, September) showed the presence of seeds of *Carissa carandas* (Fig.18). These fruit bearing trees are part of habitat areas of Jerdon's Courser.

IV. FOOD COVERAGE AND EXCRETA ANALYSIS

It is very well confirmed from analysis of fresh excreta of Jerdon's Courser that the bird feeds on ants and termites (Fig.15) The microphotograph of excreta containing parts of ants and termites is given in Fig.20. The Jerdon's Courser also feeds on ripen and fallen *Carissa carandas* fruits during season (August and September) and grains of grass (Ragivennula gaddi).

Excreta

The excreta colour seems to alter depending on the season and food it consumes. The excreta colour appears brownish black to light green to white colour The excreta was collected during the season when *Carissa carandas* bushes bear fruits and we found the excreta with carandas fruit seeds (month of July to September). During November to January it appears greenish white which might be due to feeding on grains of grass. All the times it feeds on ants and termites and excreta appears brownish black (Fig.18).

Corroboratory evidence of excreta analysis to identify food habits in other ground nesting birds –

Many attempt were made previously for the identification of food habits in ground nesting birds through excreta analysis and stomach content analysis. Lane *et al.* (1999) studied the seasonal changes in diet and diet selection of Great Bustards in North West Spain through "Faecal analysis".

Food Coverage and Corroboratory Evidence

Food and water are an essential pre-requisite for any organism. Food availability in a habitat changes with season, the organisms also change their food preferences regarding the availability of food The food spectrum, the range of food material which an animal feeds, differ from organism to organism

Jerdon was perhaps the first ornithologist to write about food of birds (Narang and Lamba, 1984) The food of many birds varies greatly according to season (Beer, 1943). Birds, especially ground nesting birds like Jerdon's Courser, Common Indian Courser, Cream-coloured courser, Indian Stone Curlew and Red-Wattled Lapwing etc, are selective feeders, and their food preferences are related to palatability The quantity of food eaten by birds varies with the type of food. Kendeigh and Charles (1934), reported that seed eating birds eat about 10% of their weight and insectivorous birds eat an amount equal to 40% of their weight daily.

The preferred food for ground nesting birds is chiefly insects (Ali and Ripley, 1969 , Gould and Rutger, 1969., Majumdar, 1984., Grimmet *et al.*, 1999). Ground nesting birds rake away with their bill the forest litter that hides their food, others scratch with feet alternately for their food. It is essential in conservation biology to know the food habits of a species, this information may useful to conserve that particular species. Many previous reports regarding the food of ground nesting birds are chiefly depend on analysis of stomach content and droppings of the birds (Moson and Lefroy, 1912, Beer, 1943. Meinertznagen, 1954., Majumdar, 1984., Hacini *et al.*, 1998., Lane *et al.*, 1999). The stomach contents of Indian Stone Curlew consists different species of insects such as *Chrotogonus, Himatismus, Componotus compresses* and *Gryllotalpa africana* (Majumdar, 1984).

The staple food, second in choice, for ground birds are seeds and berries obtained from the plant cover of its habitat. Stomach contents of Indian Sand Grouse chiefly consisted seeds of *Cyamopsis psoralioides, Eleusine artistata, Pseudanthispetria hispida* and species of *Tephrosia, Indigofera* and *Panicum* (Faruqui, 1960).

The availability of food in the habitat affects the wealth of birds by various aspects. The distribution of birds in the habitat is mainly affected by availability of food (Altamirano *et al.*, 1998). The species richness and abundance of the insectivorous birds has chiefly depend upon the species richness and abundance of the insect fauna of the habitat (Naranjo and Chachon de Ulloa, 1997) The availability of food is also play a major role in the reproductive success of ground nesting birds.

Ground birds take insect food more readily at times when insects are more abundant particularly during the months of April to September (Haase *et al.*, 1998). When reproductive needs impose, female birds take insect food, which is rich in proteins (Heinroth and Heinroth, 1955). It is presumed that there may be a relationship between protein rich insect diet and breeding season of the ground birds. The breeding season of the ground birds of Indian sub continent is during months from March to September chiefly in the month of May (Grimmett *et al.*, 1999), when the abundance of insect population is high during this season. Jerdon's Courser is also a ground nesting bird and investigations were also conducted on above lines which might help in developing appropriate conservation strategy

V. PREDATORS

Small carnivores of Jerdon's Courser's habitat in Sri Lankamalleswaram Wildlife Sanctuary

Wild Cat, Foxe, Mongoose might be primary carnivores in Jerdon's Courser's habitat Among them, mongoose were frequently observed in the thick bushes adjacent to a water streem "Pilla vanka", which pass through Jerdon's Courser's habitat. Two species of Mongooses are present in this sanctuary They are Common Indian Mongoose (*Herpestes indica*) and other species was small Indian Mongoose (*Herpestes auropunctatus*). The approximate number of these two species in Jerdon's Courser's habitat were 8-10 per 4 Sq. Km area. It is presumed that small Indian Mongoose, which feeds on small ground nesting birds and eggs and the other Common Mongoose also is a potential threat to ground nesting birds, might act as predators. A classical example is the elimination of ground nesting birds in Hawai and Puerto Rico by Mongoose (Owen 1985). The tribes in Nallamalai Forest confirmed that mongoose is also predator for ground nesting birds The mongoose moves at a terrific speed leaping in to the air, most of the ground nesting birds are fast moving on the ground and not fast flying as per literature mentioned by Burton (1975) in Encyclopaedia of Reptiles and Amphibians, they may be easily catched by mongooses. From the past historical evidence, mongooses ate the eggs of ground nesting birds Jerdon's Courser is also a ground nesting bird and based on the historical evidences, it is only presumed that Jerdon's Courser might be victim to the mongoose.

Wild Cat (*Felis silvestris*) is also a predator for ground nesting birds and known to occur in Jerdon's Courser habitat (Fig 22) Though several times searches were made, due to very small number of Jerdon's Courser birds, the predator-prey encounter could not be observed.

VI. HABITAT SHARING ANIMALS

Indian Stone Curlew (Fig.7), Common Courser (Fig.8), Blacknaped Hare, Chinkara, Peacock, Grey Francolin, Spotted Owlet, Red Wattled Lapwing, Indian Common Night jar (Fig-8a) are habitat sharing animals of Jerdon's Courser's.

VII. WATER RESOURCES

There are dried up water resource areas with holding some amount of moisture (Fig.6) that attract Jerdon's Courser. Here, the bird temporarily hides in thorny bushes seen along the stream. When the bird was disturbed in some times fly towards the thorny bush area adjoining the stream. Thus such areas are also considered as a part of bird's habitat, which offer protection.

VIII. SOIL ANALYSIS

Soil analysis was done in different soil samples collected from different areas of the sanctuary (Fig.21). The natural soil are edaphic factor that plays a major role in the conservation of habitat of Jerdon's Courser. Any change in the existing soil factor should be prevented for preservations of Jerdon's

Courser's habitat Soil analysis parameters with respect to fertility was done with a view to know whether the existing soil condition is suitable for scrub and shrub jungle or it would be succeeded by a closed type of forest, which is not an suitable habitat of Jerdon's Courser

The soil analysis data with respect to fertility only is given in Table 4 From the data presented in the Table 4, the following are the soil condition which is responsible for the existence of an open type scrub or shrub jungle Based on the soil analytical data, the soil reaction is neutral at surface and becomes slightly alkaline at lower depths due to clay migration to lower layers. The water soluble salts are lowest at the surface and increases slightly with depth and of course and this is not an impairment for plant growth, since the upper values are still below the safe permissible limits Very importantly the organic carbon content in Jerdon's Courser's habitat is typical of semiarid zone area and is very low despite it is scrub jungle High temperature and low rainfall are the causes for the poor build up of organic carbon. The stabilised ratio between carbon and nitrogen is 10:1 and the nitrogen content is poor. As long as the above situation exists, the existing habitat of Jerdon's Courser also survives, as the above situation would not stimulate the growth of forest. Thus the organic carbon is acting as a premium in maintaining the suitable habitat of Jerdon's Courser. To have the sustainability of above soil condition the following management measures have to be done

The thick forest behind Jerdon's Courser's habitat namely the mountaneous region towards West (*Fig 5*) should be preserved and no felling of trees be allowed The felling of trees would allow the dispersal and movement of rich forest litter towards the habitat area due to rain storm flood and adds the organic carbon and fertility to soil at bird's habitat area down side (Scrub Jungle). The analysis of soil was done from forested region down to scrub and shrub, where Jerdon's Courser's habitat is located. The analysis revealed that decreasing soil carbon content from forested area to plains (See Table-4) In this respect, it should be noted that the advancement of forest can be seen towards West of the Jerdon's Courser's habitat and habitat. Tall grass can be seen conspicuously in the ecotone area between forest and open scrub jungle. Further, advancement is not possible from West towards South because of the role of soil carbon Evidently in the open grounds of scrub jungle there is conspicuous absence of tall grass. We could see only grass namely "Ragivennela gaddi" (local name) on the open grounds, which is the shortest grass and found near the habitat (Fig.3). It may be concluded that the dynamic equilibrium between the forest and scrub or shrub jungle is maintained due to soil carbon or in other words the soil fertility. The low carbon level with low fertility is favourable habitat area of bird in the sanctuary

IX. HABITAT DESTRUCTION AND ANTHROPOGENIC ACTIVITY

Other than the Reddipalli area of 12 sq. km area of Sri Lankamalleswaram Wildlife Sanctuary the area towards North (Thippanapalli area) to Reddipalli area showed degradation. The degraded shrub and scrub area towards Thippana palli is a part of Sri Lankamalleswarm Wildlife Sanctuary which showed degradation can be improved with plant ratio composition prescribed for ideal habitat of Jerdon's Courser This would enable an increase in habitat area of Jerdon's Courser.

The degraded areas and their description

Thippanapalli area of Sri Lankamalleswaram Wildlife Sanctuary –

The Thippanapalli area typically represents a degraded habitat with change in plant composition and low density of scrub due to anthropogenic activity. The plant composition is given in Table-11. In this area *Dodonea viscosa* (Bandaru) is conspicuously absent where as *Maytenus emerginate* (Danti) and *Diospyros chloroxylon* (Ulindra) are less in number than that found in Jerdon's Courser area. There are *Carissa carandas* trees but their number is less and the height is also small due to anthropogenic activity. This area is unsafe for Jerdon's Courser as the numbers of trees whose branches stoop and touch surface are less (danti, ulindra and bandaru) which act as places of hiding.

Ranibavi area of Sri Lankamalleswaram Wildlife Sanctuary and degradation

The plant composition in the degraded area of Ranibavi is given in Table-14. The habitat consists of huge open grounds, the soil was very hard and lacks pebbles. The vegetation cover was almost similar to the vegetation cover present in Jerdon's Courser's habitat, but near Ranibavi, the trees are not bushy and branches are not stopping down to ground. The plant species found in Jerdon's Courser's habitat are absent or less (Table-14). Due to less number of plant species, differential soil factor and anthropogenic activity, Jerdon's Courser were not spotted. The trees are sparsely distributed with large open grounds, and termite holes are also absent or very less in this area. However, ant holes are present. Thus the above area is inhabitable for the Jerdon's Courser.

Sammanla kunta, Errakugaddalu area of Sri Lankamalleswaram Wildlife Sanctuary and degradation –

Table-12 gives the plant composition in inhabitable area of Sri Lankamalleswaram Wildlife Sanctuary, where birds were not seen. Stem height is more with out stopping down branches to surface (Fig.25). Hence, birds can not hide. Location one (Sammunu kunta) having huge open grounds and in location two (Errakugaddalu) consists small open grounds with tall grass. Plant and soil components are not suitable (Fig.25 & 26).

Impact of livestock on Jerdon's Courser and other ground nesting bird's nesting success

In Sri Lankamalleswaram Wildlife Sanctuary area many cattle belonging to Fringe Villages visit for grazing (Fig 23) It is assumed that these cattle might cause damage to ground nest of birds which consists eggs (Fig.10). It is likely that the Jerdon's Courser's eggs might also face such situation is all possibility and this could be responsible for its decline in their number Besides, browsing by goats of fine leaves might result in damage to plant cover required for the bird. The disturbance factors in the form of grazing and browsing by livestock in the sanctuary area are given in Table-12a

Comparison of degraded and ideal habitat areas of Jerdon's Courser

Table-10 presents a comparative satellite imagery data of 1998 between Jerdon's Courser's suitable habitat area and degraded area near Thippanapalli (ideal habitat description is given in Chapter-II). In the degraded area, there was 94.5% increase in open grounds, 40% decrease in dense forest, 93% decrease in mixed forest, 8 1% decrease in scrub, 54% decrease in water surface and 300% increase in agriculture than compared with Jerdon's Courser's habitat. A reversal to suitable habitat for Jerdon's Courser from degraded habitat can be achieved by appropriate plantation similar to suitable habitat. This is to increase Jerdon's Courser's habitat area. Anthropogenic activity has to be stopped

Corroboratory evidences of impact of habitat fragmentation and degradation on ground nesting birds –

Habitat fragmentation is the main threat for ground nesting birds Habitat fragmentation is mainly due to the anthropogenic activities like urbanization, industrialization and grazing by livestock. Kurki and Lindon (1995), reported that the reproductive successes of ground-nesting bird species is lower in forest landscape fragmented by the occurrence of agricultural land. Fuller and Gough (1999), reported that long time livestock grazing ground nesting birds of some regions in Britain. The decreasing population of ground nesting birds is mainly due to reduction in habitat quality, namely loss of preferred vegetation, alternation of food and alternation of predation pressure (Arnold and Weedenburg, 1998). Degradation of habitat, particularly the fragmentation through urbanization, residential development and isolation of forest habitats, is an important factor in higher rates of nest loss, which leads to the decline population of ground-nesting birds. Gutzwiller *et al.*, (1998), reported that human intrusion reduces nesting success of ground nesting birds. Hogrefe *et al* (1998) and Keyser *et al.* (1998), reported that cattle grazing on certain plants poses a potential threat to ground nesting birds, as it can create conditions that are more suitable for some species of rodents. The later are predators of ground nests of birds and they also reduce the important micro habitats of birds (Jones *et al.*, 1999).

Number of reports from the different parts of the World (Leite and Miguel, 1991, Reichnol and Josef, 1996; Macnally , 1997, Brook *et al* , 1997, Canterbury *et al* , 1997, Boulinier *et al.*, 1998; Berry *et al* , 1998; Lande, 1998; Thewlis et al 1998, Carter and Michael, 1998; Arnod and Weedenburg, 1998; Calver and Dell, 1998, Delin *et al.*, 1999, Casagrandhi *et al* , 1999 Brooks *et al* , 1999; Kimberly and Anthony, 1999, Fjeldsa, 1999 and Robinson and Robinson 1999) suggest that habitat fragmentation through anthropogenic activities is a main threat to the avifauna of the forests Forest fires are another cause for forest fragmentation thus increasing destroys large areas of suitable habitats (Recher, 1997). This is likely to strongly influence on nest failures in many endemic and endangered species of ground-nesting birds (Fotso, 1996; Woinarski, 1997). Studies on several Indian forests indicate that prevalent disturbance, mainly from fire and grazing, severely affect the regeneration of vegetation (Gaulier *et al.,* 1995; Puyravaud *et al* , 1995; Sukumar *et al.,* 1998 and, Pandey and Shukla, 2001), which is essential for survival of the avifauna. Lim (1997) reported that forest clearance associated disturbance in Singapore since 1819 is the main cause for the loss of 70 species of birds from the forest habitat. Habitat destruction and fragmentation is a primary deterministic cause for species decline, endangerment and extinction among ground nesting birds (Lande, 1998). **The present investigation also deals in this direction and other factors responsible for fragmentation of habitat and its possible impact on Jerdon's Courser.**

Chapter - II

JERDON'S COURSER'S HABITAT ANALYSIS USING REMOTE SENSING IN SRI LANKMALLESWARAM WILDLIFE SANCTUARY.

I. INTRODUCTION

II. DATA AND SOFTWARE USED

III. FIELD WORK AND GROUND TRUTHING

IV. SATELLITE REMOTE SENSING OF HABITAT OF JERDON'S COURSER AND SUGGESTIONS

V. PRESENT EXISTING HABITAT CONDITIONS IN SRI LANKAMALLESWARAM WILDLIFE SANCTUARY.

VI. FAVOURABLE HABITAT COMPONENTS OF JERDON'S COURSER.

Chapter II

1. INTRODUCTION

Habitat includes several interrelated concepts dealing with space, time and functions (Coulombe, 1977). Basically, a habitat is a sum total of environmental conditions of a specific place occupied by wildlife species or a population of such species (Thomar *et al.*, 1979). The occurrence of different wildlife species is mostly depend up on the habitat components like food, cover, water, space, other structural characteristics and the quality of the habitat itself Since the species are the product of their habitats, some dominant component of the habitat of physical variables can be used to quantify the habitat (Riclefs, 1973).

The use of satellite remote sensing and GIS is a cost effective and quicker way to generate habitat maps (Panth *et al.*, 1999, Kushwaha and Madhavan Unni, 1986, Parihar *et al.*, 1986, Singh, 1986) The real time land cover information along with their spatial distribution is a prerequisite for planning and formulations of conservation strategy for endangered wildlife

species Such an updated knowledge of the forest lands and changes in land utilization from time are obligatory for habitat evaluation (Sudhakar *et al*, 1999a). In the present study landcover such as scrub jungle, open grounds, agricultural land use, water bodies, forest areas of Sri Lankamalleswaram Wildlife Sanctuary area as well as habitat of Jerdon's Courser, were analysed for the years 1989, 1996, 1998 and 2001 followed by ground truthing.

II. DATA AND SOFTWARE USED

In the present study, IRS LISS – II and LISS – III satellite data obtained at four different time points pertaining to 1989, 1996, 1998, 2001 was taken for analysis. Hard copy out puts of the IRS LISS-II and LISS-III data were used for the study (Fig. 28, 29, 30, 31). The different sources of data used in this study were typical of many studies of land use and landcover change (Landgrebe, 1979, Raghavaswamy *et al.,* 1992; and Panth *et al.,* 1999, and Jianguo Liu *et al.*, 2001).

IRS LISS - II and LISS - III satellite imagery pertaining to larger area (78°59'12" to 79°2'24" E and 14°33'36" to 14°35'46" N) were obtained and smaller core area of the bird (79°0'48" to 79°2'24" E and 14°33'36" to 14°35'46" N) for the years 1989, 1996, 1998 and 2001 were studied and different land use classes in the area were mapped using ERDAS 8.4 Software system, ARC INFO, Mapsheet Express Software and also by visible interpretation (Windows 98 jpg) by Geomatic Center, Department of Forest, Hyderabad.

These satellite imagery were referred with the topographic maps corresponding to Survey of India, provided by Forest Department, Government of Andhra Pradesh. The Magnetic Compass was used for determination of water bearing bodies and open grounds This area was used to correlate the image tone, texture and distance for location of forest vegetation, water bodies, agricultural land use, etc

III. FIELD WORK AND GROUND TRUTHING

Ground truthing is essential in any remote sensing study (Roy *et al.*, 2001). It is the collection of ground information for its correlation with signature resulting in calibaration of the thematic units (Roy *et al.*, 1991) The land marks such as hills, open grounds, water bodies, scrub area of the above mentioned area of the sanctuary were identified by using satellite imagery and Magnetic Compass. The habitat of the selected study area for the years 1996 and 1989 was confirmed by interviewing the local people, forest officials and the forest watcher, Divisional Forest Officer and Forest Ranger, Cuddapah (A.P.) For the year 1998 to 2001 ground truthing was done by investigator. The measurement of open grounds was done by using Pedometer and compared with satellite data The values of different years were compared and calculated.

IV. SATELLITE REMOTE SENSING OF HABITAT AND SUGGESTIONS

The various land cover and their changes in Sri Lankamalleswaram Wildlife Sanctuary for the year 1989, 1996 and 1998 are given in Tables 5, 6, 7, 8, 9, 10 The visually interpreted landcover map of Jerdon's Courser's habitat consisted of 6 land use categories (Fig-31) The core habitat area comprising 4 x 3 km as well as a larger area of sanctuary comprising 7 3 x 13.1 km area was analyzed for various landcover patterns. The larger area, unlike core habitat area, includes degraded habitat also, where bird was not spotted These two areas were compared and changes in habitat components were recorded (Table-10). There was a good improvement in the actual habitat area of Jerdon's Courser comprising 4 x 3 km of area, which was verified and supported by ground truthing form 1996 to 2001. An increase of 54 % in scrub area and reduction of 71.9% in open ground from 1989 to 1996 as per satellite imagery data was noted (Table-5) Table-7 shows a randomly chosen 1 sq. km sample area which is an habitat of Jerdon's Courser, where a decrease of 55% of open land and an increase of 124% of scrub and 598% of mixed forest was observed from 1989 to 1998. The above ecological conditions and landcover now existing are ideal for Jerdon's Courser. From the situation existed in 1989, it may be assumed that before 1980 or before declaration as sanctuary in 1988, there might have been large scale destruction of scrub plants and trees in Jerdon's Courser's habitat resulting

in contiguous and large open grounds which might not be an ideal habitat requirements The 1996 satellite imagery showed a decrease in open grounds. For Jerdon's Courser small open grounds and plants listed in Table-3 help in hiding in plants unlike open grounds After 1989, the large open grounds surrounded by scrub and shrub plants have constricted The ratio of plant cover, the most dominant plants, less dominant plants etc. is given in Table-3 & 13, and this plant cover ratio was found to be an suitable habitat component for niche activities of bird. Open grounds extent of above 62.5 x 62 5 m and below 312 x 312 m are also suitable habitats but there number is less in the sanctuary than small open grounds (Table-8). The investigations by ground truthing and bird spotting revealed that open grounds of 12 5 x12.5 m to 62 5 x 62.5 m surrounded by specific plants listed in Table-3 are most suitable for Jerdon's Courser's habitat. The presence of fruit bearing tree *Carissa carandas* which is consumed by Jerdon's Courser, *Dodonea viscosa, Diospyros chloroxylon, Maytenus emerginata* (Fig.4) which offer camouflage and protection are very less in degraded areas (Table-11, 12, 14).

Due to protection offered by Forest Department, a significant and visible change was seen with progressive increase of 263% in the forested area on mountain region and at foot of the hill, but they are not habitat areas of Jerdon's Courser. However this phenomenon would prevent litter movement from mountain to down, where bird habitat is located having scrub area with open grounds. This would prevent the edaphic changes of small open grounds and scrub area where bird's habitat is found (Fig.5)

PRESENT EXISTING HABITAT CONDITIONS IN SRI LANKA-MALLESWARAM WILD LIFE SANCTUARY

The satellite imagery pertaining to the year 2001 (Fig 31) reveals the present land cover situations of Sri Lankamalleswaram Wildlife Sanctuary, where Jerdon's Courser is usually spotted. Based on the satellite imagery there is a significant improvement in the scrub jungle, which is the main habitat component of Jerdon's Courser. The Table-9 shows an increase of +49 9% of scrub jungle area and reduction of 37 4% in open grounds from 1998 to 2001. These results correlates with the census data of Jerdon's Courser collected for the period of 3 years, from 1998 to 2001. Based on this studies, it is concluded that present habitat conditions are the ideal for Jerdon's Courser for its effective survival.

VII. FAVOURABLE HABITAT COMPONENTS OF JERDON'S COURSER:

The following components are suitable for Jerdon's Courser, which was analysed after spotting the bird in different areas of the sanctuary (Table-13).

1. Plant composition and dimension as presented in Table-13, and also the general plant coverage and composition mentioned in Table-8.

2 The dead wood and twigs which attracting termites in open grounds.

3 Fallen animal droppings (Dung).

4 Termite and ant holes

5 Small size grass (The local name of grass is Ragivennula gaddi)

6 A small water stream surrounded by thorny or thick bushes

7. Presence of following order of trees *Dodonea viscosa* > *Carissa carandas* > *Maytenus emerginata* > *Acacia species* > *Diospyros chloroxylon* > *Zizyphus xylopyrus* > *Diospyros ferrea* > *Soymida febrifuga* > *Hardwickia binata*. The *Dodonea, Diospyros, Maytenus* and *Carissa* species of trees that offer shade, camouflage and hiding.

8 Soil with very low organic carbon and nitrogen (10:1) which would not stimulate the growth of forest or tall grass. Sandy clay soil with xerophytes are favourable to Jerdon's Courser (Table-4).

9 Small pebble zone

10. Small open grounds of 12.5 x 12.5 meters extent and 62.5 x 62.5 meters and 62.5 x 62 5 meters to 300 x 300 meters surrounded by thick bushes and dried up water pit with dead wood and twigs fallen on the ground (Fig.5 & 6)

Present study clearly indicates that the landcover factors now existing in Sri Lankamalleswaram Wildlife sanctuary are ideal for Jerdon's Courser, where they are frequently sighted. Birds were sighted in the habitat area of

Jerdon's Courser, but not in degraded areas of Sri Lankamalleswaram Wildlife sanctuary The satellite imagery analysis revealed that before 1980 or before declaration as sanctuary, there might have been large scale destruction of scrub plants in Jerdon's Courser's habitat resulting in contiguous open grounds which might not be an suitable habitat After 1989 and at present the small open grounds surrounded by scrub plants are found suitable habitats for Jerdon's Courser. These conditions should be maintained for the conservation of Jerdon's Courser

Several investigators studied habitats of various wildlife species of animals by remote sensing. The greatest advantage of satellite image is the synoptic view it provides which gives regional and integrated perspective of interrelation between the areas land features such as vegetation cover and open land, water bearing bodies etc., which can be better perceived on the image than on the ground (Tomar *et al.*, 1974). Panth *et al.*, (1999) studied the changes in the Sambar habitat conditions using remote sensing technology where change in food, cover, water, space and extent of edge in Corbett National Park. Similar studies were under taken by many workers in India as well as other parts of the World to evaluate the habitat of different endangered wildlife species such as elephant (*Elephas maximas*) (Sudhakar *et al* 1999a) giant pandas (*Ailuropoda melanoleuca*) (Jianguo Liu *et al.*, 2001), wild ass (*Equus heminus* Khur) (Prasad *et al*, 1994) and lion-tailed macaque (*Macaque silenus*) (Krishnamurthy *et al.*, 1998).

Chapter – III

MANAGEMENT MEASURES FOR JERDON'S COURSER'S CONSERVATION IN SRI LANKAMALLESWARAM WILDLIFE SANCTUARY

Jerdon's Courser is a critically endangered bird (Listed in Red Data Book) endemic to Sri Lankamalleswaram Wildlife Sanctuary India. Due to the low population size and the associated high risks of extinction, *ex-situ* conservation will play an important role in conservation of Jerdon's Courser. In *ex-situ* conservation, population biology will always play an important role because this task requires the consideration of reproduction, survival and dispersal rates and extinction risks. The *ex-situ* conservation is only through the establishment of ideal habitat for Jerdon's Courser in Sri Lankamalleswaram Wildlife Sanctuary This type of wildlife management was usually applied for solving the problems pertaining to a single wild species at a time, this was known as the 'single wild species approach'

followed in the European countries as well as in America (Gopal, 1992). Present dissertation also recommends the *ex-situ* conservation measures for the conservation of Jerdon's Courser The following are the management measures for the conservation of Jerdon's Courser within the sanctuary. As part of management strategy, a proper correlation need to be established between the needs of Jerdon's Courser and the welfare factors available in the habitat, which are essential for evolving a management strategy for the conservation of Jerdon's Courser.

- In the bird's habitat the tall grass type is conspicuously absent "Regivennula Gaddi" (local name) a type of grass is commonly seen and is more ideal and its seeds are consumed by Jerdon's Courser. The height of grass is 2 to 4 inches. This grass should not be allowed to be grazed by cattle of the near by villages. (However, alternative measures should be created for the villagers by Forest Department along with other government departments for fodder supply at subsidised rates.

- More importantly, the fallen dead wood and twigs should not be collected. These dead wood and twigs act as nourishment for termites which in turn act as food for Jerdon's Courser Termites and ants are rich source of proteins, which consist high calorific value. This protein rich diet (termites) may enhance the reproductive success of Jerdon's

Courser Earlier studies (Giles and Robert, 1978) on other birds have indicated that if sufficient energy is available, it can be used for reproductive purpose and also the timing of egg laying is generally constrained by female condition, which is partially determined by the food available to her before egg laying (Carriere *et al*, 1999). The termites also help in improving habitat quality namely the food cover of Jerdon's Courser Earlier studies on other bird locations have indicated that the termite activity resulted in the increase of plant cover, plant species number and rain fall use (Mando *et al*, 1999).

- Whenever natural small pits (1 ft. depth and 6 sq. ft area) are seen which has history of collection of rain water can be refilled with water 15 days once. This is because more number of excreta points of birds are seen in the dried up pits. For example 1 sq. m pit of 10 cm depth had number of excreta points (Fig 17). This partially dried up ponds attracts the aquatic insects, which are the palatable food for Jerdon's Courser. Water availability helps in habitat potential of Jerdon's Courser

- The trees of dense forested areas on the mountains towards northern parts of Reddipalli or Jerdon's Courser habitat area of sanctuary or at foot of the hill should not be cut or removed as the forest litter get flooded in to Jerdon's Courser's scrub jungle area in rainy season and

change the soil composition to enrich organic carbon This situation might stimulate growth of forest This should be avoided at any cost through preventing the soil erosion by constructing check dams The flooding of litter components due to felling of trees and other anthropogenic activities might cause forest succession and should be avoided. Thick forested areas are not ideal habitats of bird The ecotone (forest and scrub) system should be preserved.

- It is presumed that the Jerdon's Courser's habitat might have been a scrub jungle. There are endemic edaphic factors for development of scrub jungle due to low level of organic carbon and low fertility. This situation, semiarid like area seems to be an ideal habitat for Jerdon's Courser. The Forest Department needs to be analysed every year in dry months (April). The organic carbon level as well as other soil components at various points at random. The consistent monitoring would help in knowing the changes in soil and if adverse changes in soil are observed this can be rectified after identifying the natural or anthropogenic causes.

- For management, managers of Sri Lankamalleswaram Wildlife Sanctuary might collaborate with Universities for basic and applied research aspects in future. The present work is an evidence of exchange of ideas and collaboration between Forest Department and Research wing of Zoology Dept. of S.V University.

- The existing plant cover (Table 3) ratio and food coverage have to be maintained and should not be disturbed.

- The plants which offer camouflaging for Jerdon's Courser and hideouts namely *Dodonea viscosa* (Bandaru), *Maytenus emerginata* (Danti), *Diospyra chloroxylon* (Ulindra) needs plantation along with *Carissa carandas* where ever there is deficiency in the sanctuary The first three plants help in defence of the bird and the latter attracts termites and supplied ripen fruits which act as food.

- Areas where small pebble zone and above plant cover is found these habitat areas might be chain fenced (70 x 70 meters) to promote egg laying and to avoid crushing by domestic cattle.

- Jerdon's Courser is also spotted in revenue land area of Veera Reddy Chelaka, 50 meters away from sanctuary limit. This adjacent areas may be procured with due compensation in coordinating with Revenue Officers to further enhance actual core habitat of the bird.

- The Thippanapalli and Ranibavi areas which are towards northern part of sanctuary is highly degraded (see Chapter-1). These areas needs partial plantation similar to plant composition mentioned in Table-3 like *Carissa carandas*, *Maytenus emerginata*, *Dodonea viscosa* etc. This is to increase Jerdon's Courser's habitat and also reduces the predation risk.

- Southern side of Sri Lankamalleswaram Wildlife Sanctuary area namely Samanla kunta, is highly degraded and its soil factor and plant composition is different from Jerdon's Courser's habitat area Table 11 gives inhabitable area and plant composition This Samanla kunta area of sanctuary cannot be rectified.

- The birds spotting have to be done and monitored every month to know its status (Pairs, or Single, number)

- The visits by tourists may be arranged but "light flash" by cameras have to be avoided. The bird experiences "light shock" and have to be avoided. This would allow frequent visit to habitat area.

- The Reddipalli villagers have to be prevented from taking *Dodonea viscosa* (Bandaru) twigs or plant leaves. These leaves are considered as waste and are used as bed for cattle and also allowing putrefaction to use as manure for agriculture. This plant helps in hiding and is found in good number in Courser's habitat area (Fig. 3 & 4 and Table-3).

- Tourists pass through Ranibavi and proceed to Venugopala Swamy Temple located in the dense forested area of sanctuary This area consists waterfalls attracting tourists in sanctuary area. Tourists come for picnic via Pasupugundam area of sanctuary should be advised and educated by erecting posters not to use fire crackers or sounding horn

during festival time. The presence of tourists has resulted in made carnivores to move towards Courser's habitat area and disturb its ecology. At forest check post near Ranibavi, the officials have to check for firecrackers A few visitors are unruly and found in inebriated condition due to alcohol consumption This needs to be checked

- In view of assumption made in Chapter-I on predators, monitoring of mongoose and wild cat population need to be taken up Any encounter with Courser or its eggs needs a further study.

- Jerdon's Courser should not be radio collared or held in captivity in hand or cage as the animal is delicate and might die of fear. This condition is based on experience during observation by earlier investigators 15 years ago. Earlier studies on radio collaring of Gray partridge, which is a ground nesting bird, indicates that the radio collaring is a threat for survival, reproductive success and body mass of the bird (Elisabeth and Francois, 1999). Caizergues (1998) studies on radio collaring of Black Grouse, which is also a ground nesting bird, indicates that the radio collaring reduce the reproductive success of the individual. In view of very few birds (Jerdon's Courser) radio collaring would be detrimental and should be avoided.

- Watch tower has to be constructed near "Medaravanikunta" away from open ground where birds come for feeding. The watchtower help in observing bird's movements towards its habitat and nest. This information is essential for conservation of the nests and eggs of Jerdon's Courser. The monitoring of above factors help in under standing bird movement, nesting etc.

- Satellite imagery of Sri Lankamalleswaram Wildlife Sanctuary have to be taken every year and changes in forest shrub and scrub jungle, water resources, agricultural landuse and other anthropogenic activities have to be monitored and appropriate measures have to taken If drastic changes are observed in Jerdon's Courser's habitat, this has to be observed by ground truthing and appropriate action plan has to be taken.

- Photography of Jerdon's Courser by visitors with flash should be banned because this bird is sensitive to light and out of fear excretes However the photography of Jerdon's courser in Sri Lankamalleswaram Wildlife Sanctuary may be allowed for Ornithological researchers with prior permission of Chief Wildlife Wardon, Govt of Andhra Pradesh

For effective management of Sri Lankamalleswaram Wildlife Sanctuary, where Jerdon's Courser was usually spotted, the local people should be involved in conservation of the wildlife including Jerdon's Courser under Joint Forestry Management Programme of Govt. of Andhra Pradesh (Balakrishna, 2000) This type of community based conservation method was adopted for many protected areas in India as well as other parts of the World (Mehta and Stephen, 1998, Ghate, 1998, Balakrishna, 2000). The Wildlife Protection Act should be strictly implemented in the sanctuary by Andhra Pradesh Forest Department for the conservation of Jerdon's Courser and its habitat.

Summary

Jerdon's Courser (*Cursorius bitorquatus*) is a "Critically Endangered" Red Data Book bird. Bird sightings, ecology and habitat components analysis by satellite remote sensing and ground truthing were done to suggest management measures in Sri Lankamalleswaram Wildlife Sanctuary

1 Bird sightings in the habitat area as well as in other areas of Sri Lankamalleswaram Wildlife Sanctuary were compiled for the years 1998 to 2001. Birds were seen in small open grounds of scrub jungle frequently in Veera Reddy Chaelaka, Regikayala Kunta Badava, Maederavanikunta barakalu and Dhaggoni Chaelaka. They were also sighted, though less frequently in other scrub patch areas with in the sanctuary (Table-1e).

2 The plant cover of Jerdon's Courser's habitat showed that *Carissa carandas, Dodonea viscosa, Maytenus emergenata* and *Diospyros chloroxylon* are more important among plant species. The plant species in the habitat of Jerdon's Courser in the sanctuary is listed. The ecological role of these plants in offering food, defense and hide out was found to be of great importance.

3 Jerdon's courser feeds on *Carissa carandas* ripen and fallen fruits, grass seeds and termites. The excreta analysis revealed residual components of above food through out the study period.

4 The Common Indian Courser (*Cursorius coromandelicus*), Indian Stone Curlew (*Burhinus oedicremus*), Red-wattled Lapıng (*Venellus indicus*), Common Indian Nightjar (*Caprimulgus asiaticus*), Chestnut bellied Sandgrouse (*Pterocles exustus*), Painted Sandgrouse (*Pterocles indicus*), Grey Francolin (*Francolinus pondicerianus*) and Eurasian Collared - Dove (*Streptopelia decaocto*) were found to shares the habitat of Jerdon's Courser

5. It is presumed that wildcat (*Felis silvestris*) and mongoose (*Herpestes indica* and *Herpestes auropunctatus*) seem to be the predators of Jerdon's Courser Although no direct predation was observed during the study. The Jerdon's Courser's eggs may also get tangled by livestock that frequently grazes in its habitat.

6. Very importantly the organic carbon content in Jerdon's Courser's habitat is typical of semiarid zone area and is very low despite the habitat being scrub jungle. High temperature and low rainfall are the causes for the poor build up of organic carbon The stabilized ratio between carbon and nitrogen is 10:1 and the nitrogen content is poor. As long as the above situation exists, the existing habitat of

Jerdon's Courser also survives, as the above situation would not stimulate the growth of forest Thus, the organic carbon is acting as a premium in maintaining required conditions for Jerdon's Courser. The ecotone area where forest followed by scrub jungle is observed, the trees should not be cut and particularly on the mountain region. Which might cause flooding of forest litter during rainy season into scrub jungle. This might cause change in soil composition, and might promote forest which is not congenial habitat of Jerdon's Courser.

7. Jerdon's Courser's habitat components were also analysed using satellite remote sensing method for the years 1989, 1996, 1998 and 2001 using imagery obtained through IRS LISS-II and IRS LISS-III Satellites

8. IRS LISS-II and LISS-III satellite imagery pertaining to larger area (78^0 59' 12" to $79^0$2' 24" E and 14^0 33' 36" to $14^0$35' 46'N) were obtained and smaller habitat area of the bird (79^0 0' 48" to 79^0 2' 24" E and 14^0 33' 66" to 14^0 35' 46" N) were for the years 1989, 1996, 1998 and 2001, and different land use classes in the area were mapped using ERDAS 8.4 Software system, ARC INFO, Mapsheet Express Software. Visible interpretation of these maps were done at Geomatic Centre, Dept. of Forest, Hyderabad by the investigator.

9 The satellite imagery analysis revealed that before 1980 or before declaration as Sanctuary, there might have been large-scale destruction of scrub plants in Jerdon's Courser's habitat resulting in contiguous open grounds which might not be a suitable habitat After 1989 and at present the small open grounds surrounded by scrub plants are found to be favourable habitats for Jerdon's Courser. These conditions should be sustained for the conservation of Jerdon's Courser.

10 Open grounds of above extent 62.5 x 62 5 m and below 312 x 312 m are also suitable habitats but its number is less in the sanctuary than small open grounds. The investigation by ground truthing and bird spotting revealed that open grounds of 12 5 x 12 5 m to 62.5 x 62.5 m surrounded by plants, such as *Carissa carandas, Maytenus emerginata, Dodonea viscosa* and *Diospyros chloroxylon* are most favourable for Jerdon's Courser's habitat

11 Based on the Satellite imagery, it was found that there was an increase of 49.9% of scrub jungle area and reduction of 37 4% in open ground from 1998 to 2001. These results correlate with the census data of Jerdon's Courser collected for the period of 3 years from 1998 to 2001 in the habitat areas. Thus it is concluded that present habitat conditions seem to be congenial for Jerdon's Courser.

12 A comparative satellite imagery data on Jerdon's Courser's habitat area and degraded area near Thippanapalli revealed that, in the degraded area there was 94.5% increase in open grounds, 93% decrease in mixed forest, 8.1% decrease in scrub, 54% decrease in a water surface and 300% increase in agriculture than compared with Jerdon's Courser's habitat area. A reversal to suitable habitat of Jerdon's Courser from degraded areas can be achieved by appropriate plantation similar to ideal habitat presented in dissertation

13. In this sanctuary the biotic interference in the form of collection of forest products by local inhabitants, cattle grazing, looping, bullock cart should be avoided These are potential threat for the survival and nesting success of Jerdon's Courser in its habitat.

14 To lessen the anthropogenic pressers on bird's micro habitat requirements, it is suggested that the fallen deadwood and twigs should not be collected, as these act as nourishment for termites on which Jerdon's Courser feeds

15 The Thippanapalli and Ranibavi areas, which towards northern part of sanctuary, are highly degraded areas These areas need partial plantations similar to plant composition found in habitat.

16 The visits by tourists may be arranged but light flash by cameras has to be avoided The bird experiences "light shock" and excretes by fear and have to be avoided This would allow frequent visit of birds to habitat area.

17. Jerdon's Courser should not be radio collared or held in captivity in hand or cage as the animal is delicate and might die of fear

18 It is hoped that this dissertation might be of help to Dept of Forest, Ornithologists and Environmentalists to help in saving the "Critically Endangered" bird.

Table 1(a): Survey of Jerdon's courser in the habitat area (12 sq.km) of Sri Lankamalleswaram Wildlife Sanctuary where birds are frequently sighted during 1998 July to 1999 June*

Sl No.	Month	Location Name and Number of Birds sighted				Mean No of Birds Sighted
		Regikayalakunta and Number of Birds Sighted	Veerareddychaelaka and Number of Birds Sighted	Mederavanikunta Barakalu and No of Birds Sighted	Dhaggoni chaelaka and No. of Birds Sighted	
1.	July' 98	2	4	2	--	9
2.	August' 98	2	4	1	2	9
3	September'98	1	4	3	1	9
4.	October'98	2	6	2	2	12
5.	November'98	2	4	3	2	11
6	December'98	2	6	2	2	12
7.	January'99	2	5	2	1	10
8.	February'99	2	4	3	2	11
9.	March'99	3	6	2	2	13
10.	April'99	2	4	--	2	8
11	May'99	1	4	2	2	9
12	June'99	2	4	2	2	10
						Mean = 10

Note: The birds are signed and counted on new moon and successive 2nd day and mean is taken into consideration

Table 1(b): Survey of Jerdon's courser in the habitat area (12 sq.km) of Sri Lankamalleswaram Wildlife Sanctuary where birds are frequently sighted during 1999 July to 2000 June*

Sl. No	Month	Location Name and Number of Birds sighted				Mean No of Birds sighted
		Regikayalakunta and Number of Birds Sighted	Veerareddychaelaka and Number of Birds Sighted	Mederavanikunta Barakalu and No of Birds Sighted	Dhaggoni chaelaka and No of Birds Sighted	
1.	July' 99	3	4	4	2	13
2.	August' 99	2	6	3	3	14
3.	September'99	2	4	2	2	10
4.	October'99	1	4	3	3	11
5.	November'99	--	4	2	2	8
6.	December'99	4	6	4	2	16
7.	January'2k	3	5	3	3	14
8.	February'2k	4	6	4	2	16
9.	March'2k	2	4	3	--	9
10.	April'2k	2	3	4	2	11
11.	May'2k	3	4	2	2	13
12.	June'2k	4	4	2	2	12
						Mean = 12

Note: The birds are signed and counted on new moon and successive 2nd day and mean is taken into consideration.

Table 1(c): Survey of Jerdon's courser in the habitat area (12 sq.km) of Sri Lankamalleswaram Wildlife Sanctuary where birds are frequently sighted during 2000 July to 2001 June

Sl. No.	Month	Location Name and Number of Birds sighted				Mean No of Birds sighted
		Regikayalakunta and Number of Birds Sighted	Veerareddychaelaka and Number of Birds Sighted	Mederavanikunta Barakalu and No of Birds Sighted	Dhaggoni chaelaka and No of Birds Sighted	
1.	July' 2k	2	4	2	4	12
2.	August' 2k	3	5	4	3	15
3	September'	2	6	5	6	19
4.	October	--	5	2	4	17
5.	November	4	8	5	--	17
6.	December	4	5	4	3	16
7.	January	4	6	3	4	17
8.	February	3	6	4	3	16
9.	March	5	7	6	4	22
10.	April	2	4	4	--	10
11.	May	2	4	2	4	12
12.	June	4	6	4	4	18
						Mean = 15

Note: The birds are signed and counted on new moon and successive 2nd day and mean is taken into consideration

Table I(d): Population density of Jerdon's Courser during 1998-2001 in the habitat area (12 Sq. Km) of Sri Lankamalleswaram Wildlife Sanctuary.

S.No.	Duration	Total Number of Birds spotted. (Mean)	Population density = No. of animals sighted / Area Sq. Km
1.	July'98 to June'99	10	10/12 = 0 835 Km^2
2.	July' 99 to June' 2k	12	12/12 = 1 Km^2
3.	July, 2k to June 2k	15	15/12 = 1.2 Km^2

Note As there exist no data on ecology of this bird, it is presumed that the increase in bird population and density is purely due to search efficiency, but not due to their ecological increase in population.

Table I(e): Survey of Jerdon's Courser in different locations of Sri Lankamalleswaram Wildlife Sanctuary (100 sq.km), other than habitat area.

Sl. No.	Month	Location Name and Number of Birds spotted								
		Boddipadala narava Number of Birds Spotted			Budda Chaelaka Number of Birds Spotted			Peddadagu vanka Number of Spotted		
		1998-99	1999-2000	2000-2001	1998-99	1999-2000	2000-2001	1998-99	1999-2000	2000-2001
1.	July' 2k	--	1	1	--	1	1	1	1	1
2.	August' 2k	1	1	2	1	2	1	1	1	2
3.	September'	1	1	1	1	1	2	1	--	1
4.	October	1	--	--	1	1	1	1	1	1
5.	November	2	2	1	2	2	2	2	3	3
6.	December	2	2	3	1	1	3	3	3	3
7.	January	1	2	2	1	1	2	3	1	2
8	February	2	1	2	1	1	2	1	1	2
9.	March	2	--	--	1	1	1	1	1	1
10	April	--	--	1	1	1	1	--	1	1
11.	May	--	1	1	1	--	1	--	1	1
12.	June	1	1	2	1	1	1	2	2	2

Table I (f): Consolidated table giving total mean number of birds sighted in Sri Lankamalleswaram Wildlife Sanctuary (in habitat area and other locations)*

Sl.No.	Years	Total number of birds Sighted		Total Mean Value
		Core niche	Other locations	
1	1998-99	10	3	16 3 birds / 12 sq km
2	1999-2000	12	3	
3	2000-2001	15	4	

* Sri Lankamalleswaram Wildlife Sanctuary total area declared is 465 sq km which includes dense and mixed forests and mountains The birds probable habitat area comprises only 12 sq km

Table.2 Number of excreta points of Jerdon's Courser in different locations of Sri Lankamalleswaram Wildlife Sanctuary.

Sl No	Month	Location and number of excreta points			
		Regikayala kunta badava	Veera Reddy Chaelaka	Medaravami kunta barakalu	Dhaggoni chaelaka
1	July	-	6	4	-
2	August	-	-	8	-
3	September	2	4	6	1
4	October	-	1	3	-
5.	November	-	-	1	-
6	December	1	17	5	1
7	January	-	-	3	2
8	February	-	-	1	-
9.	March	-	1	2	-
10.	April	-	2	4	-
11	May	-	-	-	-
12.	June	-	3	-	2

Note The excreta points are counted per 100 x 100 mtr area

Ragikayala kunta badava = 1 5 sq. km
Veera Reddy Chaelaka = 2 sq. km
Medaravami kunta = 2 sq. km
Dhaggoni chaelaka = 1.2 sq km

Table 3. Vegetation cover in Jerdon's Courser's habitat in Sri Lankamalleswaram Wildlife Sanctuary. The plant numbers are mean of 6 spots of size of 20 x 20 m. (0.4 sq.km) in habitat area (4 x 3 km) of the bird in different locations.

Sl No	Location	Name of the plant	No of the plants in open ground Per 0.4 sq km	Height of the plants (ft)
1	Veera Reddy chaelaka	*1 Carissa carandas*(Kalivi)	33	3-9
		2 Zizyphus xylopyrus (Gotti)	21	5-20
		3 Dodonea viscose (Bandaru)	48	5
		4 Maytenus emerginata (Danti)	16	3-7
		5 Diospyros chloroxylon(Ulindara)	6	8
		6 Hardwickia binata (Nara epi)	1	5-20
		7 Torenia asiatica (kommi)	5	2-10
		8 Diospyros ferra (Ooty)	3	3-10
2	Medaravani kunta barakalu	*1 Carissa carandas*(Kalivi)	17	3-9
		2 Zizyphus xylopyrus (Gotti)	6	5-20
		3 Dodonea viscose (Bandaru)	27	5
		4 Maytenus emerginata (Danti)	10	3-7
		5 Diospyros chloroxylon (Ulindara)	5	2-10
		6 Hardwickia binata (Nara epi)	2	5-10
		7 Torenia asiatica (kommi)	1	2-10
		8 Diospyros ferra (Ooty)	2	3-10
		9 Soymida febrifuga	3	5-15

Contd.,

Sl No	Location	Name of the plant	No of the plants in open ground per 0 4 sq km	Height of the plants (ft)
1	Another location of Medaravanikunta baralkalu	*1 Carissa carandas (Kalivi)*	22	3-9
		2 Zizyphus xylophyrus(Gotti)	2	5-20
		3 Dodonaea viscosa (Bandaru)	60	5
		4 Maytenus emerginata (Danti)	20	3-7
		5 Diospyros chloroxylon (Ulindara)	2	2-10
		6 Hardwickia binata (Nara epi)	2	5-10
		7 Torenia asiatica (kommi)	1	2-10
		8 Diospyros ferrea (Ooty)	2	3-10
		9 Soymida febrifuga	2	5-15
		10 Accasia latronum (Jala)	8	5-10

Table.4: Soil analysis data of different locations of Sri Lankamalleswaram Wild life Sanctuary.

Soil Collected Area	pH	Level	Electrical conductivity	Level	Organic Carbon	Phosphates (kg/acre)	Level	Potash	Soil nature
Up-hill	7 1	Neutral	0 21	Normal	Medium	3 6	Low	7448	Sandy clay
Foot hill	8 7	more alkaline	0 11	"	Medium	6 4	"	121	"
Mixed forest	8 7	"	0 11	"	Low	8 1	"	211	"
Jerdon's Courser Niche	8 6	"	0 1	"	Low	6	"	161	"
Jerdon's Courser Niche (Revenue land)	7 1	Neutral	0 13	"	Low	4 14	"	170	"
Degraded forest (Tippana palli)	8 4	alkaline	0 41	"	Low	6	"	211	"

Note Values are mean of six samples of select areas.

Table.5 Satellite (IRS LISS II & III) imagery data on % change in Jerdon's courser habitat components from 1989 to 1996 (3 X 4 km)

Sl No	Habitat components	Area in Sq Km		% change
		1989	1996	
1	Scrub jungle	5 918	9 122	+54
2	Open land	5 208	1 4623	-71 9
3	Agricultural land	0 356	0 1575	-55 7
4	Water bodies	0.125	0 48	+287 88
5	Mixed forest	0 25	0 274	+7 6
6	Dense forest	0 135	0.5037	+263

Table.6 Satellite (IRS LISS II & III)* imagery data on % change in Jerdon's courser habitat component changes in larger area of Sri Lankamalleswaram Wildlife Sanctuary (7.3 X 13.1 km) from 1989 to 1996.

Sl No	Habitat components	Area in Sq Km.		% change
		1989	1996	
1	Scrub jungle	48.21	44 9	-6 86
2.	Open land	29.62	12 49	-57 81
3.	Agricultural land	4 25	5 1	-20 11
4.	Water bodies	2.31	5.8	124 5
5	Mixed forest	3 47	9 3	+168 48
6.	Dense forest	1 97	14 9	+652 98
7.	Shadow	5.86	3 21	--

Table.7 Satellite imagery data of 1989-1998 (IRS LISS II & III) and changes in 1 sq.km sample plot of habitat niche area.

Satellite imagery data verified by ground truthing (area of analysis = 1sq.km)

Sl No	Habitat component	Area in sq km		% change from 1989 to 1998
		1989	1998	
1	Open land	0 647	0 290	-55
2	Dense forest	0.0026	0 035	+1246
3	Mixed forest	0 0053	0 037	+598
4	Scrub	0 270	0.607	+124
5	Water	0.0133	0 0133	-
6	Agriculture	0 05	0.005	-90

Note: These 1 sq km plot was chosen from Jerdon's Courser's favourable habitat, where Jerdon's Courser was frequently seen.

Table-8. Satellite imagery data showing Pattern of open grounds in the scrub jungle area of Jerdon's Courser habitat from 1989 to 1998

Category 'A' and 'B' open grounds are suitable habitats.

Sl No	Location Name	Year of satellite imagery	Number of open ground islands / sq km			
			A	B	C	D
1	Jerdon's Courser core niche area, near Reddi palli, where Jerdon's Courser was spotted	1989	2.6	0 714	0 803	0 446
		1996	16 4	3.5	1 33	0 53
		1998	9 8	4 2	0 89	1 78

A = Open grounds extent 12 5 x 12.5 m to 62.5 x 62.5 m

B = Open grounds extent 62.5 x 65.5 to 312.5 x 312 5 m

C = Open grounds extent 468.75 x 468.75 to 625 x 625 m

D = Open grounds extent above 625 x 625 m

Table-9. **Satellite imagery data showing the percent change in land cover situation from 1998 to 2001 in Sri Lankamalleswaram Wildlife Sanctuary (95.7 sq.km) with respect to scrub and open ground.**

S.No	Land Cover	Percent Change
1.	Scrub Jungle	40 9%
2	Open land	-32 4%
3.	Agricultural land	* 44.6%
4	Water bodies	# - 36 5%

Note: * As per revenue records agricultural land very adjacent to sanctuary shows increase when cultivated and decrease when not cultivated The data need not be considered as encroachment of agricultural land.

\# Water bodies and irrigation reservoirs gets filled in some years and and donot get filled during drought years or when monsoon fails

Table.10 Satellite data (IRS LISS III) showing comparison of land cover in degraded and habitat area of Jerdon's courser in 1998 and after ground truthing.

(See increase in open grounds in degraded area).

Sl No	Habitat component	Name of location and percent change in land cover				
		Jerdon's courser core niche area near Reddipalli Where Jerdon's courser was spotted (sq km)	Tippanapalli Where Jerdon's courser was not spotted (sq km)	Percent change over Jerdon's Courser's habitat	Southern part of Lanka Malleswaram Sanctuary where Jerdon's courser was not spotted (sq km)	Percent change over Jerdon's Courser's habitat
1.	Open land	0.22	0 428	+94 5	0 56	+154 5
2	Dense forest	0 035	0 021	-40	0.01	-71
3	Mixed forest	0 17	0 0116	-93	0 02	-88 2
4	Scrub	0 557	0 5116	-8 1	0 375	-32 6
5	Water	0.0133	0 006	-54	0.005	-62 4
6	Agriculture	0.005	0 020	+300	0 03	+500

Table.11 **The plant cover from highest to least occurrence in the degraded Thippanapalli scrub area (A part of Lankamalleswaram Wildlife Sanctuary towards north of Jerdon's Courser habitat), where Jerdon's Courser was not spotted.**

Sl No.	Name of the plant species	Occurrence	Soil structure	Remarks (A comparison with Jerdon's courser area)
1	*Carissa carandas* (kalivi)	+++++++++	The soil in this area is sandy clay	Conspicuously Maytenus emerginata Diospyros chloroxylon trees are very less in number. In this area the scrubs (2-3 thorny bushes) are sparsely distributed without open grounds. Dodonaea viscosa trees are absent. Scrub are more than shrub and there are no trees
2.	*Acacia latronum* (Jala)	++++++	The soil is soft with less pebbels and more stones	
3	*Soymida febrifuga* (sommi)	+++++	Very low organic carbon with less fertility but ideal for plant required for Jerdon's courser habitat	
4.	*Zizyphus xylophyrus* (Gotti)	++++		
5.	*Diospyros chloroxylon* (Ullindia)	+++		
6	*Maytenus emerginata* (danti)	++ Inverted pyramid		

Table.12 Percent change in plant cover (different species) in degraded habitat compared to plant cover in favourable habitat of Jerdon's Courser in Lankamalleswaram Sanctuary. The plots selected consisted 20 X 20 meters (0.4 Sq.Km).

Sl No	Name of location of degraded scrub,where Jerdon's courser was not spotted	Plant species	Normal height (ft)	Number of plants	Percent change in degraded area over ideal habitat	Remarks on degraded habitat
1	Sammanla kunta (Adjacent to Alturu cross road)	a *Carissa carandas*(Kalivi)	3 to 6	6	-81 8%	
		b *Zizyphus xylopyrus* (Gotti)	10 to 20	85	+304%	
		c *Dodonaea Viscosa* (Bandaru)	3 to 5	-	-100%	
		d *Maytenus emerginata* (Danti)	3 to 7	8	-50%	
		e *Diospyros chloroxylon* (ulindra)	8 to 10	2	-66%	Buds were not seen Stem height is more without stooping of branches to surface Hence birds can not hide Location one (Sammanu kunta) having huge open ground and in location two (Erraku gaddalu) consists small open grounds with tall grass Plant and soil components are not ideal (Fig 25 & 26)
		f *Hardwicia binata* (Naraepi)	8 to 20	8	+700%	
		g *Torenia asiatica* (Kommi)	3 to 4	3	-40%	
2	Erraku gaddalu	a *Carissa carandas*(Kalivi)	3 to 9	4	-76 4%	
		b *Zizyphus xylopyrus* (Gotti)	10 to 20	88	+1366%	
		c *Dodonaea Viscosa* (Bandaru)	2 to 5	2	-92 5%	
		d *Maytenus emerginata* (danti)	3 to 7	8	-20%	
		e *Diospyros chloroxylon* (ulindra)	2 to 10	2	-60%	
		f *Hardwicia binata* (Naraepi)	10 to 20	18	+125%	
		g *Torenia acedica* (Kommi)	2 to 10	2	-100%	

Table - 12a

Disturbance factor:

Live stock which visit Sri Lankamalleswaram Wildlife Sanctuary, 57 nearby villages in a year (2002).

S.No.	Disturbance factors	Number / frequency	Time spent in Browsing / grazing	
			Months	Hours/day
1.	Cows and Buffaloes	4000-5000	9 – 12	6 – 8
2.	Goat	500-600	12	6 – 9
3.	Sheep	1000-1500	12	6 – 8

Table.13 Description of Components of favourable habitat of Jerdon's Courser

Location Name and Area of the Open ground	Dominated plant species	Height of the plant and Number		Number of dead fallen twigs	Number of termite holes/ 1 sq.m	Number of buffalo dung Points	Number of termite infected trees	Lux value Day time	
		No	Height					On the Ground	Under Bushes
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
10 X 10 mt (Location Where Jerdon's Courser was Spotted)	*Carissa carandas*	8	3 to 6 ft	11	6	1	6	72500	14500
	Dodonaea viscosa	15	3 to 5 ft						
	Maytenus emerginata	6	3 to 10ft						
	Acacia latronum	8	6 to 12ft						
	Diospyros chloroxylon	1	6 to 12ft						
	Zizyphus xylopyrus	1	10 to 20ft						

Contd.,

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
20 X 20 mt	*Carissa carandas*	17	3 to 6ft						
	Dodonaea viscosa	27	3 to 5ft						
	Maytenus emerginata	3	3 to 10ft						
	Acacia latronum	13	8 to12ft	50	5	6	11	72500	14500
	Diospyros chloroxylon	2	10 to 12ft						
	Zizyphus xylopyrus	1	15 to 20ft						
	Harwicia binata	1	15 to 30ft						
	Torenia acidica	1	3 to 5 ft						

Table. 14 Vegetation cover up in two selected plots of degraded habitat near Ranibavi area of Sri Lankamalleswaram Wildlife Sanctuary and % change over habitat area of Jerdon's Courser.

Sl No	Name of the species	No of plants	% change over Jerdon's Courser's habitat	Habitat description
I	*Carissa carandas* (Kalivi)	11	-66%	The habitat consists of huge open grounds, the soil was very hard with out pebbels The vegetation cover up was almost similar to the vegetation cover up present in Jerdon's Courser's habitat, but near Ranibavi, the trees are not bushy and branches are not stooping down to ground. The plant species found in Jerdon's courser habitat are absent or less (Table-3a & 3b) Due to less protection of plant species, different soil factor and anthropogenic activity, the Jerdon's courser birds are not spotted The trees are sparsely distributed with large open grounds, and termite holes are also absent or very less in this area. However ant holes are present. Thus the above area is inhabitable for the Jerdon's courser
	Zizyphus xylopyrus (gotti)	-	-	
	Dodonaea viscosa (bandaru)	28	-41%	
	Maytenus emergmata (danti)	6	-62 5%	
	Drospyros chloroxylon(ulindra)	1	-83%	
	Soymida febrifuga (sommi)	2	-60%	
II	*Carissa carandas* (Kalivi)	8	+33%	
	Zizyphus xylophyrus (gotti)	24	+33%	
	Dodonaea viscosa (bandaru)	26	-48%	
	Maytenus emergmata (danti)	6	+40%	
	Drospyros chloroxylon(ulindra)	-	-	
	Soymida febrifuga (sommi)	1	+7 36%	

Legend for Fig-1:

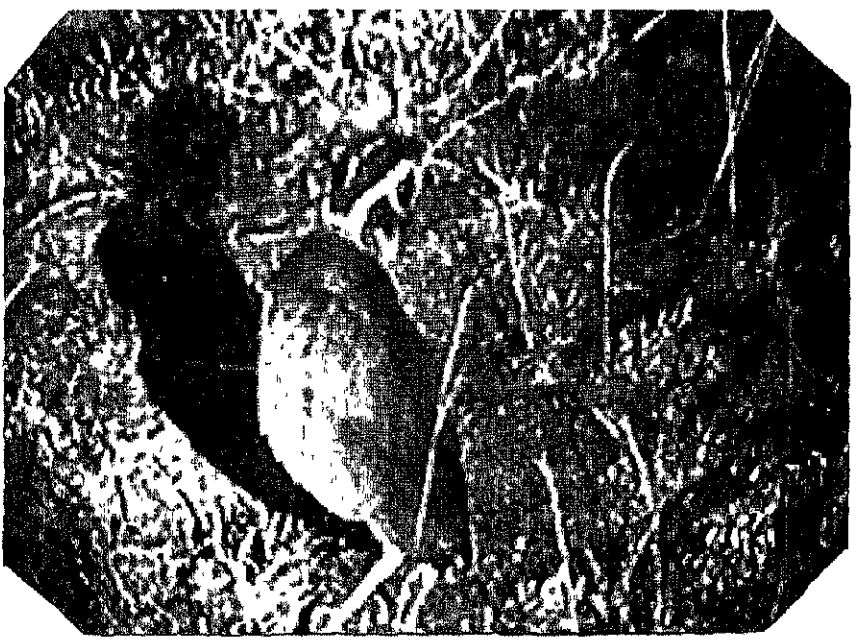
Front View of Jerdon's Courser. Double bands across the breast, which are the main characteristic features of the bird are clearly seen. (Photographs were reproduced from Television Screen)

Legend for Fig-2:

Dorsal view of the head of Jerdon's Courser. The Crown on the head is clearly seen. (Photographs were reproduced from Television Screen).

Figure –1

Figure –2



Legend for Fig-3:

A close view of Jerdon's Courser's habitat with small open ground surrounded by thick bushes Dead fallen twigs of *Canssa carandas* and small grass are seen

Legend for Fig-4:

Jerdon's Courser's suitable habitat and open ground with *Maytennus emerginata, Dodonea viscosa, Diospyrus chloroxylon* and *Canssa Carandas* bushes. Branches Stoop down to ground is an advantage for bird in hiding.

Figure –3

Figure –4

Legend for Fig-5:

Long view of the scrub jungle of Sri Lankamalleswaram Wildlife Sanctuary with mountain. Behind this dense forest is observed in the Western side of the mountain.

Legend for Fig-6:

A partially dried up water pool of Jerdon's Courser's habitat in Sri Lankamalleswaram Wildlife Sanctuary.

Figure –5

Figure –6

Legend for Fig-7:

Habitat sharing ground nesting bird, Indian Stone Curlew (*Burhinus oedicnemus*) in Jerdon's Courser's habitat. The colour of the bird is camouflage with the small pebbles and surroundings.

Legend for Fig-8:

Another habitat sharing nocturnal ground nesting bird, The Common Courser (*Cursorius coromandalicus*) of Lankamalleswaram Sanctuary.

Figure –7

Figure –8

Legend for Figure.8a

Common Indian Nightjar (*caprimulgus asiaticus*), a habitat sharing ground nesting bird of Jerdon's Courser's habitat in Sri Lankamalleswaram Wildlife Sanctuary.

Figure –8a

Legend for Fig.9

The egg of Indian Stone Curlew on shallow unlined scrap on stony ground at the base of *Zizyphus* bush

Legend for Fig.10

The eggs of Grey Francolin (*Francolinus pondicerianus*) in the nest lined with grass and leaves placed under the bush of *Dodonea viscosa*.

Figure –9

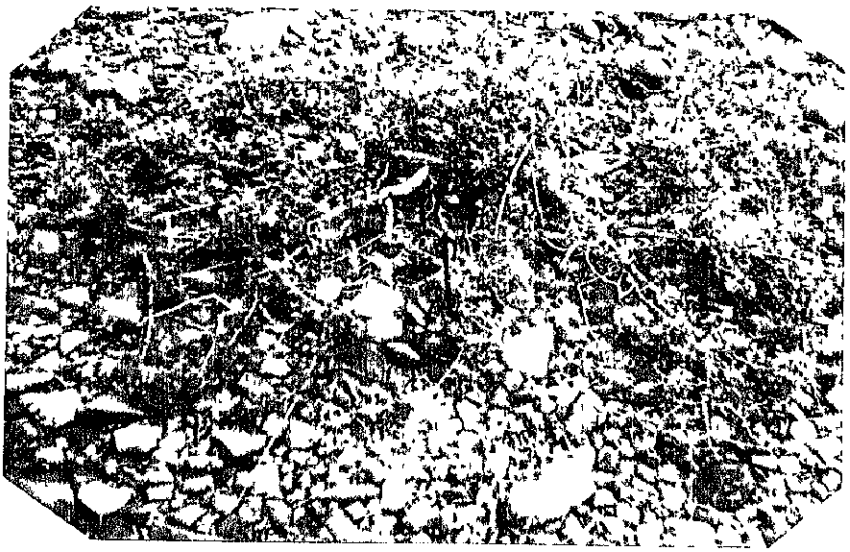
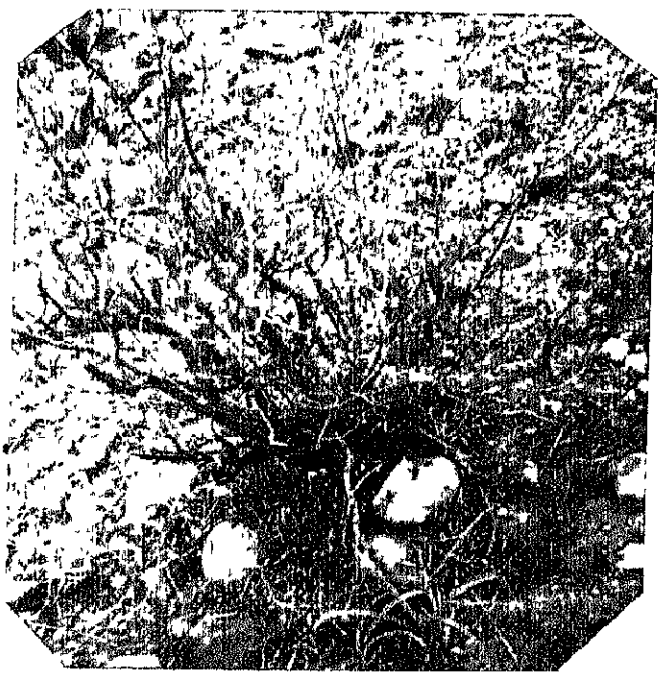


Figure –10



Legend for Fig.11

Red-wattled Lapwing (*Vanellus indicus*) nest with four eggs. The nest is a natural depression on the ground parapetted with bits of dry cow dung

Legend for Fig.12

The broken egg of Red-wattled Lapwing in Jerdon's Courser's habitat in the ground, nest lined with small pebbles This can be crushed by cattle and the eggs are camouflaged with pebbles and surroundings.

Figure –11

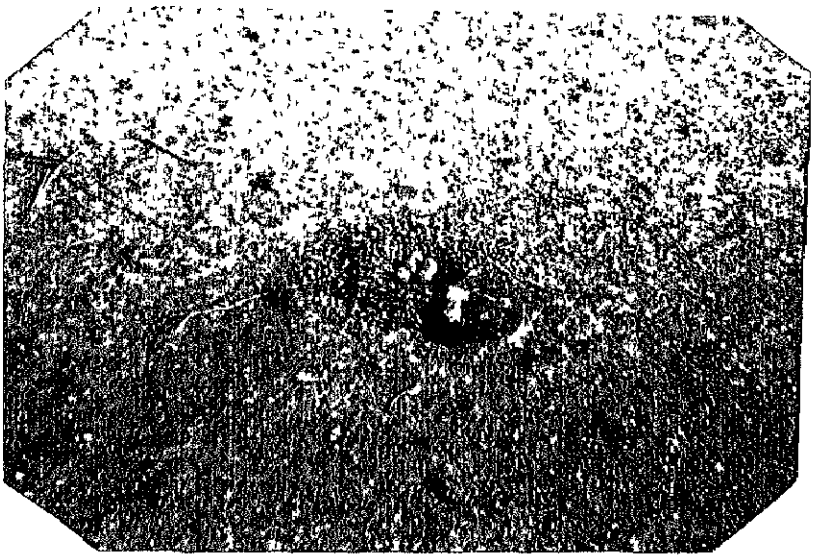
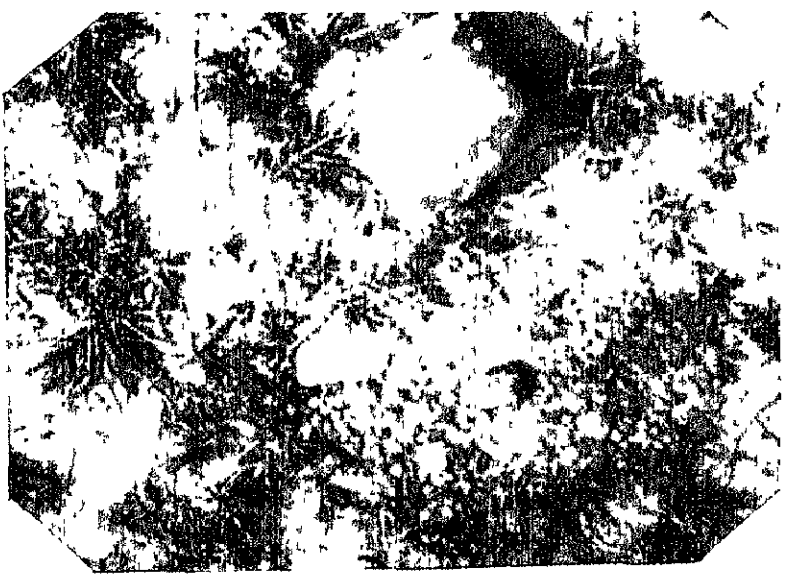


Figure –12



Legend for Fig.13

Carissa carandas tree bark infested with termites, which is the palatable food for Jerdon's Courser.

Legend for Fig.14

Termite hole in Jerdon's Courser's habitat. Pointed by white coloured pointer.

Figure –13

Figure –14

Legend for Fig.15

Large number of termites comes out during night from the termite hole The Jerdon's Courser was found near this termite hole feeding on termites.

Legend for Fig.16

Termites found in the habitat are of Jerdon's Courser in Sri Lankamalleswaram Wildlife Sanctuary.

A) Termites, which are collected from termite infested cow dung and humus.

B) Termites, which are collected from termite infested *Carissa carandas* tree bark.

C) Termites, which are collected from termite hole.

Figure –15

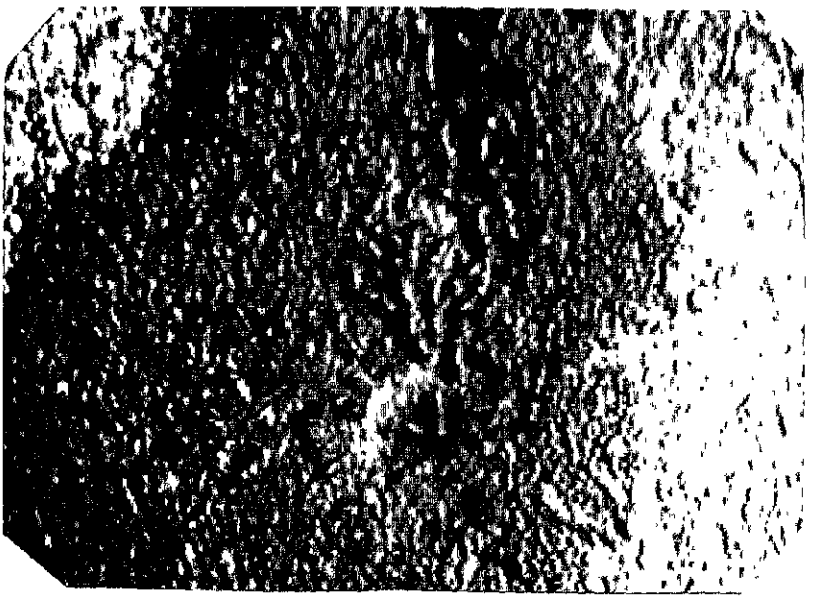
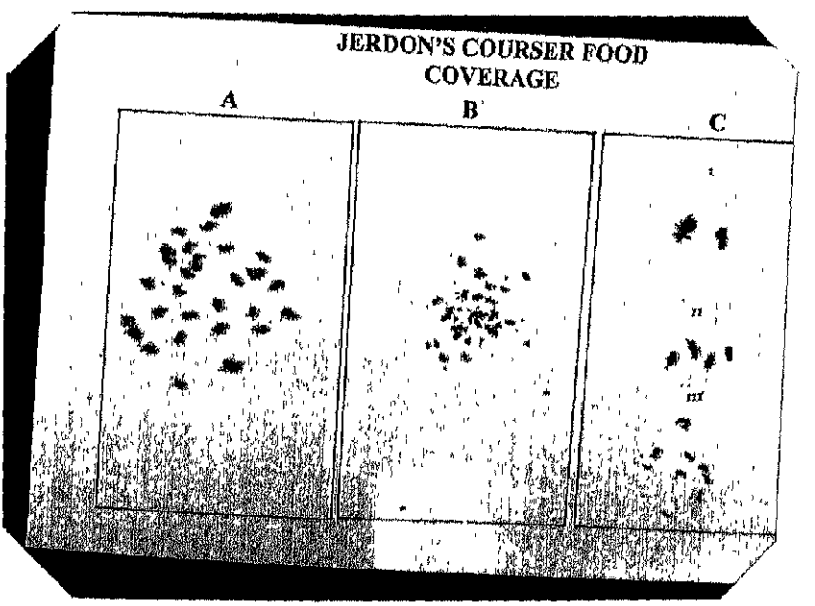


Figure –16



Legend for Fig.17

A dried up water pool, where Jerdon's Courser's excreta is seen (white spots in the figure).

Legend for Fig-18

Excreta of Jerdon's Courser and Common Courser.

The differentiation between two species excreta was clearly seen Jerdon's Courser excreta.

a) Collected during the season of November and December consists grass grains with tinge of green colour.

b) Collected during the season of *Carisa carrandas* fruit bearing (July to September). The excreta consists the seeds of *Carissa* and the colour of the excreta is also black with *Carissa* fruit nut.

c) Excreta of Jerdon's Courser in almost all season's Consists parts of termite and ants. See Figure 19 and 20 also for microscopic detail.

Figure –17

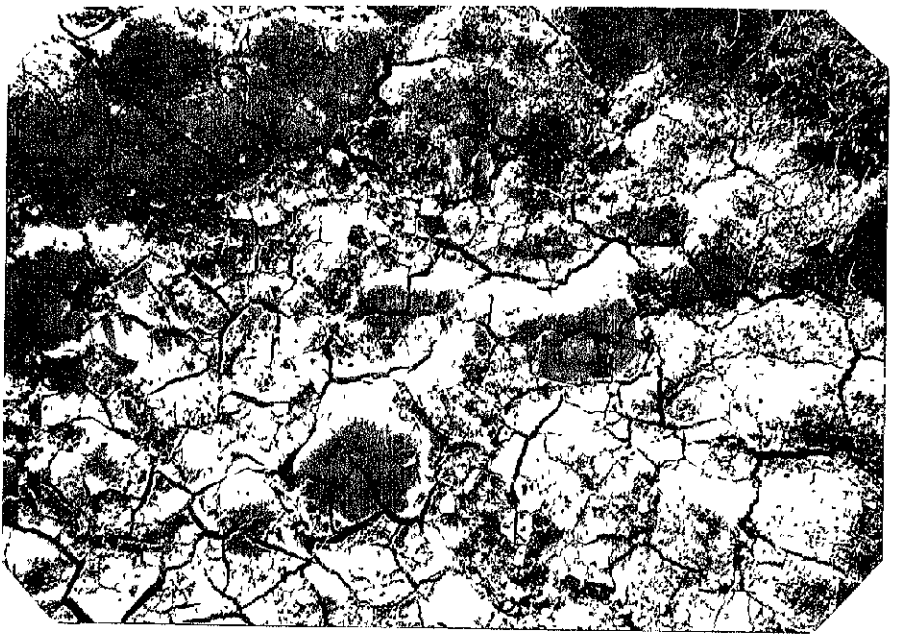
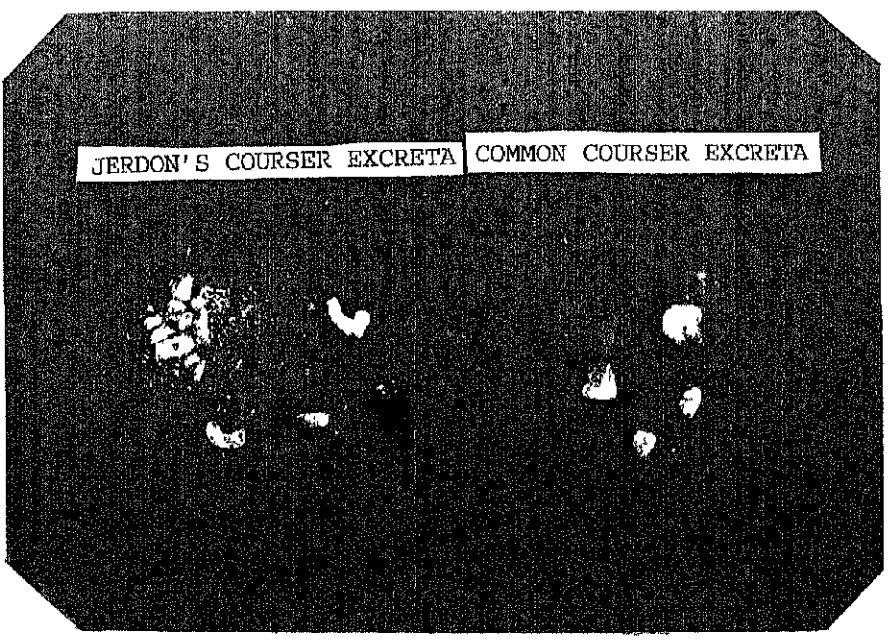


Figure –18



Legend for Fig.19

Fresh excreta of Jerdon's Couser collected after spotting the bird.

Legend for Fig.20

Micro photograph of Jerdon's Courser excreta showing chitinous parts of termites and ants, a conformation of food of Jerdon's Courser.

Figure –19

Figure –20

Legend for Fig.21

Soil samples collected from different locations of Sri Lankamalleswaram Wildlife Sanctuary for analysis.

1. Up-hill forested fertile area.
2. Foot hill forested fertile area
3. Mixed forest area

4&5 Jerdon's Courser's habitat.

6. A degraded area (Thippanapalli)
7. Lime nodules of subterranean soil of Jerdon's Courser's habitat.

Legend for Fig.22

Pug marks of Jerdon's Courser, indicates the absence of back facing toe and pug marks of wild cat are also seen.

Figure –21

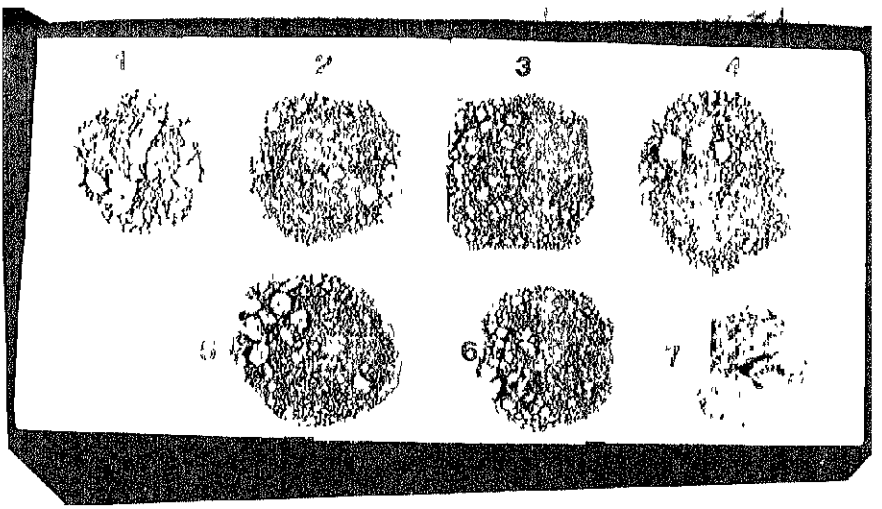


Figure –22

Legend for Fig.23

Livestock (cattles) of Jerdon's Courser, which is a potential threat to the nesting success of ground nesting birds

Legend for Fig.24

Anthropogenic activities in Jerdon's Courser's habitat

See below (arrow) the eggs of Lapwing's nest.

See just above the egg nest the removal of *Hardwicia binata* plants indicating the threat due to Anthropogenic activities

Figure –23

Figure –24

Legend for Fig.25

Habitat degradation through anthropogenic activities and forest fires in Sri Lankamalleswaram Wildlife Sancturary where Jerdon's Courser was not spotted.

Vegetation cover was not suitable for survival of Jerdon's Courser.

Legend for Fig.26

Degraded forest of Lankamalleswaram Sanctuary adjacent to Jerdon's Courser's habitat (Samanla kunta). Plant composition is not suitable for Jerdon's Courser.

Figure –25

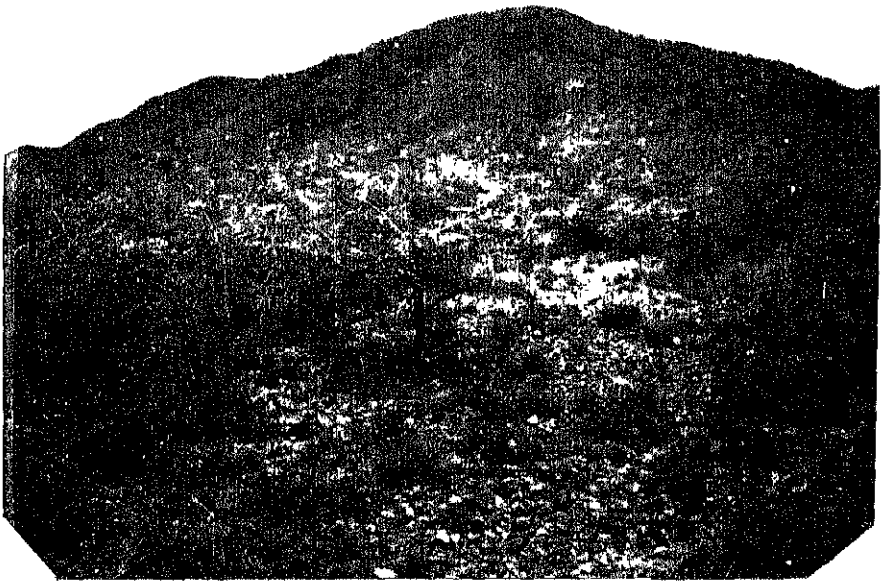
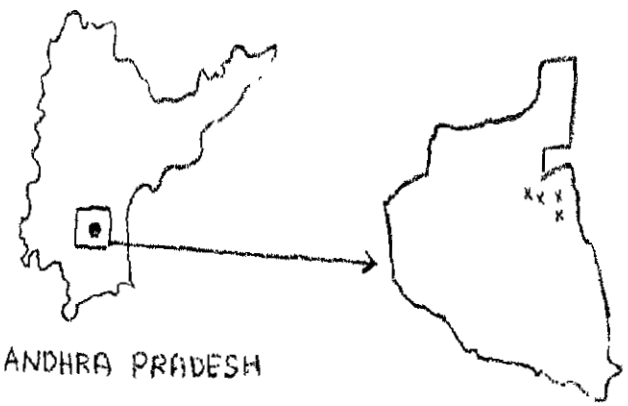


Figure –26

FIG.26A

MAP SHOWING LOCATION OF SRI LANKAMALLESWARAM WILDLIFE SANCTUARY IN ANDHRA PRADESH, INDIA.



SRI LANKAMALESWARAM WILDLIFE SANCTUARY AND JERDON'S COURSER'S HABITAT

SURVEY MAP OF SRI LANKAMALLESWARAM WILDLIFE SANCTUARY SHOWING THE LOCALITIES OF JERDON'S COURSER'S HABITAT (STUDY AREA)

78°45' 50' 55' 79°

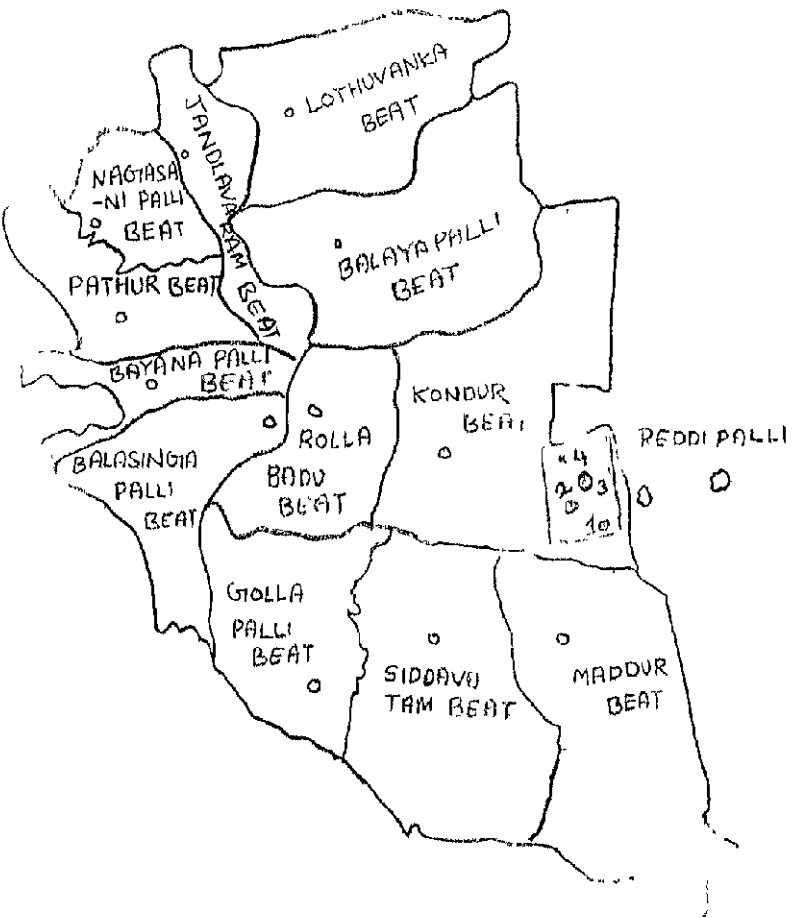


FIG.26B

⊕ Study area (Jerdon's Courser's Habitat)

1 = Veera Reddy Chaelaka
2 = Medaravani Kunta barakalu
3 = Ragikayalakunta badava
4 = Dhaggoni chaelaka

Source: Survey of India, sheet No: 57 1/14

Legend for Fig.27

IRS LISS III unclassified satellite imagery of Lankamalleswaram Sanctuary.

Figure –27

SATELLITE IMAGERY OF PULICAT LAKE AMALLESWARAM SANCTUARY
(A HEAVEN FOR PELICANS COURSER HABITAT)
N

Legend for Fig.28

IRS LISS II classified Satellite imagery of Lankamalleswaram Sanctuary for the year 1989. (Satellite imagery was taken only a part of Lankamalleswaram Wildlife Sanctuary includes Jerdon's Courser's habitat and degraded area)

See the contiguous open lands or large open lands with least or no scrub plants. These large open lands are not suitable habitats for Jerdon's Courser. The situation existed in 1989 and before

⊙ Study area

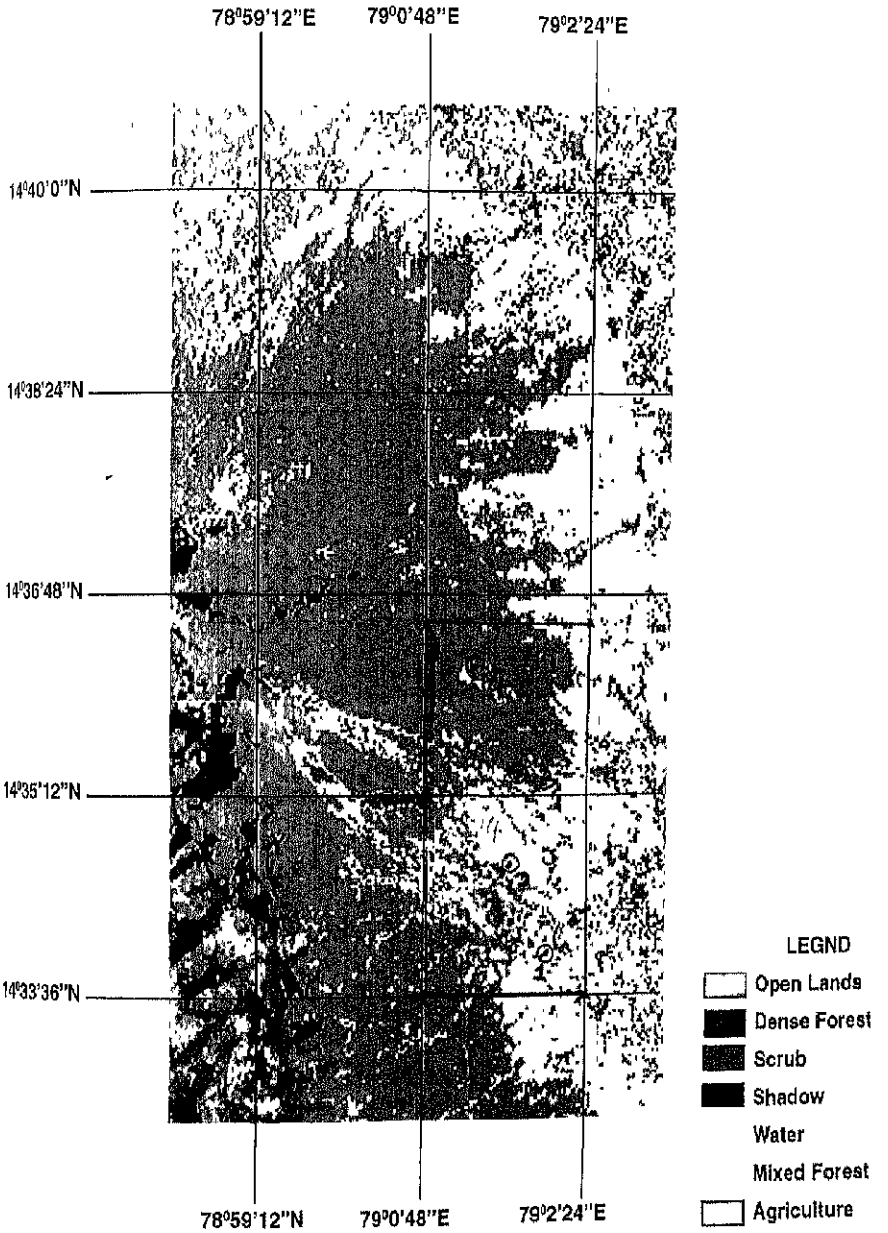
1 = Veera Reddy chaelaka

2 = Ragikayalakunta badava

3 = Mederavanikunta barakalu

4 = Dhaggoni chaelaka

CLASSIFIED LISS II IMAGE OF LANKAMALLESWARAM SANCTUARY (JERDON'S COURSER HABITAT)



DATE OF PASS FEB .89

Legend for Fig.29

IRS LISS III classified Satellite imagery of Lankamalleswaram Sanctuary for the year 1996 (Satellite imagery was taken only a part of Lankamalleswaram Wildlife Sanctuary includes Jerdon's Courser's habitat and degraded area).

See the open lands with scrub plants thus there is reduction of large open lands to small open lands surrounded by scrub plants, which are suitable habitats for Jerdon's Courser. This situation exists since 1996 onwards.

⊙ **Study area**

1 = Veera Reddy chaelaka

2 = Ragikayalakunta badava

3 = Mederavanikunta barakalu

4 = Dhaggoni chaelaka

CLASSIFIED LISS III IMAGE OF LANKAMALLESWARAM SANCTUARY (JERDON'S COURSER HABITAT)

78°59'12"E 79°0'48"E 79°2'24"E

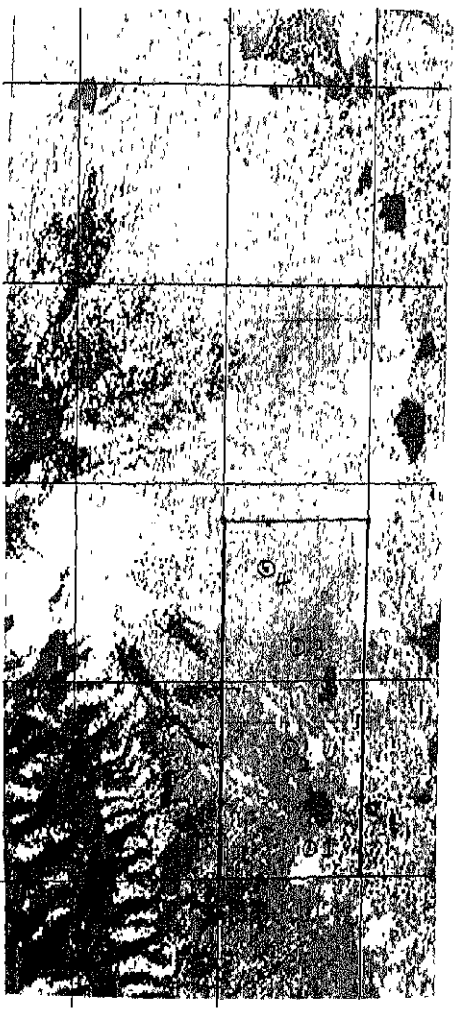
14°40'0"N

14°38'24"N

14°36'48"N

14°35'12"N

14°33'36"N



78°59'12"N 79°0'48"E 79°2'24"E

LEGND

- Open Lands
- Dense Fgrest
- Scrub
- Shadow
- Water
- Mixed Forest
- Agriculture

PASS

DATE OF 2ND DEC. 96

Legend for Fig.30

IRS LISS III classified Satellite imagery of Lankamalleswaram Sanctuary for the year 1998 (Satellite imagery was taken only a part of Lankamalleswaram Wildlife Sanctuary includes Jerdon's Courser's habitat and degraded area).

See the open lands with scrub plants thus there is reduction of large open lands to small open lands surrounded by scrub plants, which are suitable habitats for Jerdon's Courser This situation exists since 1996 onwards.

⊙ **Study area**

1 = Veera Reddy chaelaka

2 = Ragikayalakunta badava

3 = Mederavanikunta barakalu

4 = Dhaggoni chaelaka

Figure –30

Legend for Fig.31

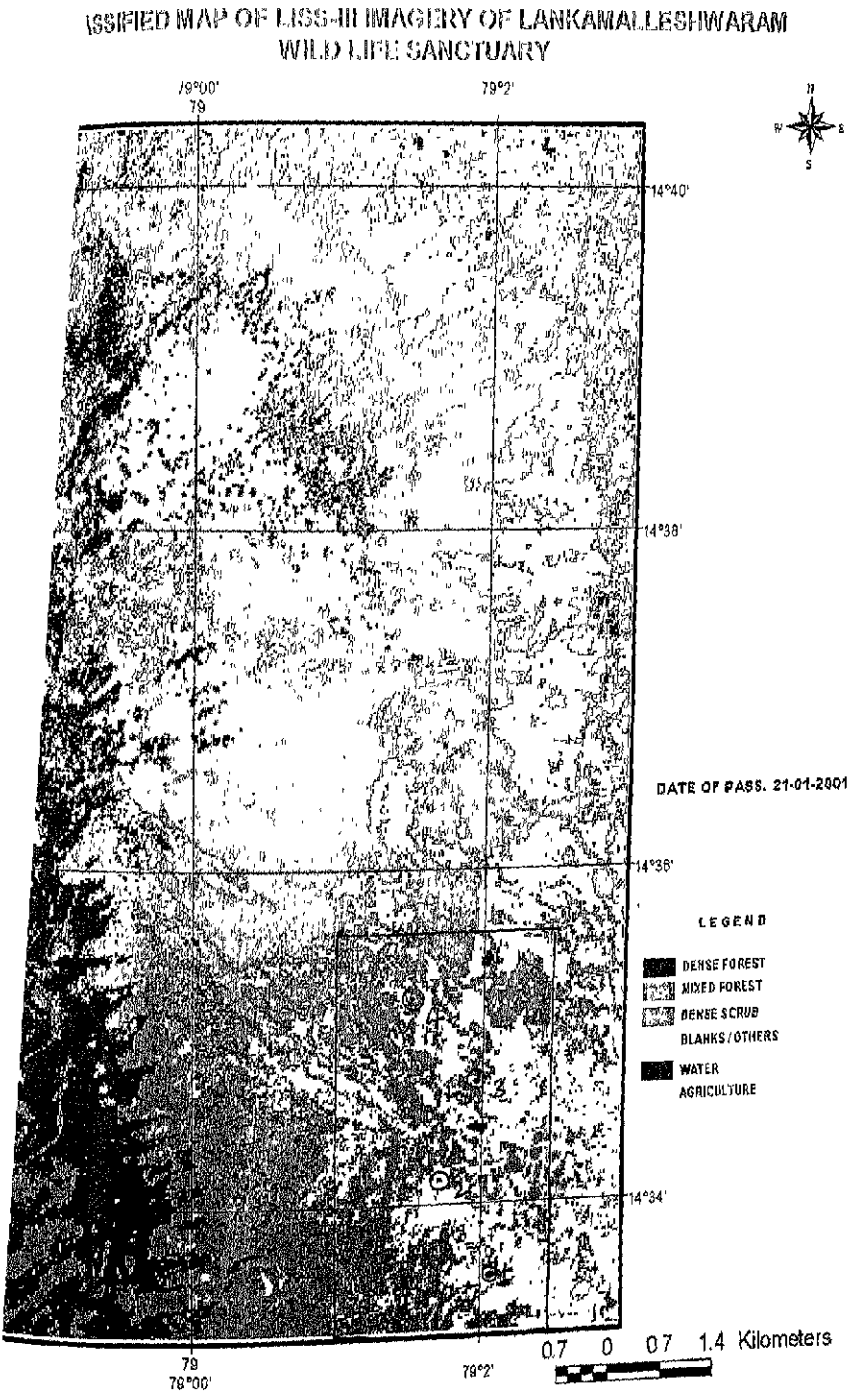
IRS LISS III classified Satellite imagery of Lankamalleswaram sanctuary for the year 2001 (Satellite imagery was taken only a part of Lankamalleswaram Wildlife Sanctuary includes Jerdon's Courser's habitat and degraded area)

See the open lands with scrub plants thus there is reduction of large open lands to small open lands surrounded by scrub plants, which are suitable habitats for Jerdon's Courser This situation exists since 1990 onwards

⊙ Study area

1. Veera Reddy chaelaka
2. Rangkayalakunta badava
3. Medaravankunta barakalu
4. *Dhaggom* chaelaka

Figure –31


ISSIFIED MAP OF LISS-III IMAGERY OF LANKAMALLESHWARAM
WILD LIFE SANCTUARY
79°00'
79
79°2'
14°40'
14°38'
14°36'
14°34'
N
W
E
S
DATE OF PASS. 21-01-2001
LEGEND
DENSE FOREST
MIXED FOREST
SCRUB
BLANKS / OTHERS
WATER
AGRICULTURE
0.7 0 0.7 1.4 Kilometers

Photonirvachak
Journal of the Indian Society of Remote Sensing, Vol 29, No 1&2, 2001

Jerdon's Courser Habitat Analysis Using Remote Sensing

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Government of Andhra Pradesh
Hyderabad - 4

ABSTRACT

Jerdon's courser (*Cursorius bitorquatus*) considered as lost bird is found in Sri Lankamalleswaram Sanctuary, Cuddapah District, Andhra Pradesh. It is listed in Red data book as endangered bird. Analysis of satellite imagery of 1989, 1996, 1998 and ground information have revealed an improvement of Jerdon courser's habitat after declaration of area as sanctuary in 1988. Large open grounds show a decrease while small open grounds surrounded by scrub plants offering protection and food cover increase. Analysis of satellite imagery shows core niche covering 4 x 3 km area and larger area of sanctuary (7.3 x 13.1 km) having various land cover classes. Comparison of satellite imagery from 1989 to 1998 shows degradation of larger area of sanctuary where birds are not seen.

Introduction

Jerdon's courser (*Cursorius bitorquatus*) also known as double - banded courser, derives its name from *Dr. Jerdon T C*, an army surgeon of Nellore town. Jerdon recorded it from the hilly country above the Eastern Ghats of Nellore and Cuddapah districts of Andhra Pradesh in 1848. The bird was not seen after 1848 and was considered as extinct (Tikader, 1983). later on bird was seen in the Pennar Valley in 1900 (Tikader, 1983). For more than 80 years, the bird surveys and special exploration were made by prominent organisations like Smithsonian Institute (USA) which proved futile. This nocturnal bird was hence presumed extinct. A local resident near Lankamalleswaram sanctuary, Ithanna, caught one bird and had shown to Salim Ali, a renowned Ornithologist of India in 1986. The Andhra Pradesh Government in 1988 has declared 465 sq km area of Lankamalleswaram forest in Cuddapah district as Wildlife Sanctuary for the protection of Jerdon's courser.

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The use of satellite remote sensing and GIS is a cost effective and quicker way to generate habitat maps (Roy et al, 1986, Kushwaha and Madhavan, 1986, Panthar et al, 1986, Singh, 1986) Pant et al (1999) studied the Sambar habitat conditions using remote sensing technology and have prepared a habitat suitability map of Sambar in Corbett National Park The suitable areas are found to show a good correlation with the preferences for the parameters like food, cover disturbance tolerance, terrain characteristics, crussing radii for water etc In the present study land cover such as scrub jungle, open grounds, agricultural land use, water bodies, forest cover of Sri Lankamalleswaram Wildlife Sanctuary area as well as niche (functional status of bird in an ecosystem) of Jerdon's courser, were analysed for the years 1989, 1996 and 1998

Study Area

Cradled in the isolated Lankamalleswaram hills with red sander forest, the pristine Lankamalleswaram Sanctuary spreads over an area of 465 sq km in Cuddapah district of Andhra Pradesh The forests in the sanctuary vary from deciduous red sander forest on the hill to scrub area in the plains The study area is the scrub area where Jerdon's courser bird is usually spotted The plant species in the scrub area include *Carissa carandas, Dodonea viscosa, Maytenus emerginata, Diospyros chloroxylon, Hardwickia binata, Toreria asiatica, Zizyphus xylopyrus and Acacia latronum* Among the birds, Jerdon's courser, common courser, nightjars, stone curlew, grey patridge are commonly sighted In the present study, scrub area and forest (7 3 × 13 1 km) and a core niche area of 4 × 3 km for the years 1989, 1996 and 1998 have been analyzed using remote sensing and GIS techniques

Materials and methods

IRS LISS - II and LISS - III satellite imageries pertaining to larger area (78°59'12" to 79 2'24" E and 14°33'36" to 14°35'46" N) were obtained and smaller core area of the bird (79 0'48" to 79°2'24" E and 14°33'36" to 14°35'46" N) for the years 1989, 1996 and 1998 were studied and different land use classes in the area were mapped using ERDAS 8 4 software system and ARC INFO, Mapsheet Express Software and also by visible interpretation

Results and discussion

The area of various Jerdon's courser land cover classes and their changes in Lankamalleswaram Sanctuary for the years 1989, 1996 and 1998 are given in Tables 1 and 2 The core niche area comprising 4 × 3 km as well as a larger area of sanctuary 7 3 13 1 km was analyzed for various land cover classes The larger area, unlike core niche area includes degraded habitat, where bird was not spotted These two areas were compared and changes in habitat components were recorded There was good improvement in the actual niche and habitat area of Jerdon's courser comprising 4 x 3 km of area, which was verified and supported by ground truthing from 1996 to 1999 Table 1 shows an increase of 54% in scrub area and reduction of 71.9% in open ground from 1989 to 1996 as per satellite imagery of these years Table 2 shows a randomly chosen 1 sq km area which is an actual niche area, where a decrease of 55% of open land and an increase of 124% of scrub and 168% of mixed forest was observed from 1989 to 1998 The above ecological conditions and land cover now existing are ideal for Jerdon's courser From the ground situation existing in 1989 it may be assumed that before 1980 or before declaration of the area as sanctuary in 1988, there might have been large scale destruction of scrub plants and trees in Jerdon's courser habitat area resulting in contiguous and large open grounds which might not be an ideal habitat requirement This is clearly seen in satellite imagery of 1989 (Fig 1) The 1996 satellite imagery shows a decrease in open grounds (Fig 2) For Jerdon's courser small open grounds and plants help habitat in hiding in

Fig 2 Classified satellite image of Sri Lankamalleswaram Sanctuary for December 1996

Classified satellite image of Sri Lankamalleswaram Sanctuary for February 1989

University, Tirupati-517502 (A.P.)

plants unlike open grounds After 1989, the large open grounds surrounded by scrub and shrub plants decreases The shrub plant was found to be an ideal habitat component for niche activities of bird Open grounds of size above 62 5 × 62 5 m and below 312 × 312 m are also ideal for habitats but their number is less in the sanctuary than small open grounds Detailed studies and bird spotting have revealed that open grounds of 12 5 × 12 5m to 62 5 × 62 5 m surrounded by specific plants are most ideal for Jerdon's courser niche and habitat Whereas in Thippanapalli area, location in the same sanctuary represents degraded habitat areas where Jerdon's courser is not sighted The presence of fruit bearing tree *Carissa carandas* which is consumed by Jerdon's courser, *Dodonea viscosa, Diospyros chloroxylon, Maytenus emerginata* which offer camouflage and protection are very less in degraded area

Due to protection offered by Department of Forest, a significant and visible change was seen with progressive increase of 263% in the forested area on mountain range and at foot of the hill but they are not habitat areas of Jerdon's courser (Table 1) However, this phenomenon will prevent litter movement from mountain to lower areas, where bird habitat is located having scrub area with open grounds This will prevent the edaphic changes of small open grounds and scrub area where birds habitat is found

Conclusions

The present study clearly indicates that the land cover exist in Lankamalleswaram sanctuary

Table 1: Land cover situation in 1989, 1996 and 1998 in Jerdon's courser niche area (a) 1 sq km and (b) 12 sq km

Land Cover	Study area in different years					
	(a) 1 sq km			(b) 4 x 3 = 12 sq km		
	1989	1998	% change	1989	1996	%change
Open land	0 647	0 29	-55	5 208	1 4625	-71 9
Dense forest	0 0026	0 035	+1246	0 138	0 5037	+263
Mixed forest	0 0053	0 037	+598	0 25	0 274	+7 6
Scrub	0 270	0 607	+124	5 918	9 122	+54
Water bearing bodies	0 0133	0 0133	-	0 125	0 48	+287 9
Agricultural land	0 05	0 005	-90	0 356	0 1575	-55 7

Table 2: Land cover situation in 1989, 1996 in Lankamalleswaram sanctuary (7 3 x 13 1 km)

Land cover	Area sq km		% Change
	1989	1996	
Scrub jungle	48 21	44 9	-6 86
Open land	29 62	12 49	-57 81
Agricultural land	4 25	5 1	+20 11
Water bodies	2 31	5 8	+124 5
Mixed forest	3 47	9 3	+168 18
Dense forest	1 97	14 9	+652 98
Shadow	5 86	3 21	-

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are ideal for Jerdon's courser, where they are frequently seen Birds are seen in the ideal niche area of Jerdon's courser, but not in degraded areas of Lankamalleswaram sanctuary The analysis of satellite imagery for the years 1989 and 1996 have revealed that before 1980 or before declaration of area as sanctuary, there might have been large scale destruction of scrub forest in Jerdon's courser habitat resulting in contiguous open grounds which might not be an ideal habitat After 1989 due to closing of area the population of scrub plants increased and the size of open grounds decreased presently the small open grounds surrounded by scrub plants are ideal habitats for Jerdon's courser These conditions should be maintained for the conservation of Jerdon's courser

Acknowledgements

One of the authors (Prof N V. Nanda Kumar) is highly thankful to Mr S D Mucherjee, Principal Chief Conservator and Dr. T Ramakrishna, Chief Wild Life Warden and Head, Geometric Center, Department of Forest for project funding and GIS analysis

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Aquaculture Effluent Effect on Physicochemical Characteristics and Zoo Plankton of Pulicat Lake Bird Sanctuary

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ABSTRACT

Pulicat lake sanctuary attracts thousands of migratory and non-migratory birds for feeding The Publicat lake water physicochemical and hydro biological characteristics were analysed at different depths in a year. The aquaculture effluent was found to affect significantly BOD, carbonates, inorganic phosphates and plankton population density The aquaculture effluent caused 48%–100% mortalities among the Pulicat lake zooplankton during 30–90 min period of exposure The studies revealed that the release of aquaculture effluent would drastically affect the primary consumers and thus indirectly pose a threat to plankton feeders on which the migratory birds survive

Key words : *Pulicat lake sanctury, Plankton, Aquaculture effluents*

Introduction

Pulicat lake sanctuary supports a rich biodiversity of aquatic and terrestrial birds and a variety of zoo and phytoplankton and a variety of nekton The Pulicat lake sanctuary is the second largest brackish water lake in India 70 Km long and 1–20 Km wide covering approximatley 600 Sq Km (A P Forest Department, 1997) spreading in the states of Andhra Pradesh and Tamilnadu. It is formed out of back waters of Bay of Bengal with depth ranging from 0 2-4 meters adjoined by rivers, riverlets and a number of streams. The Pulicat lake sanctuary is being visited by migratory birds namely flamingoes, pelicans, painted stroks, openbilled stroks, Grey herons, Cormorants, Ibises, Egrets, rivertern, Waders, besides a number of non-migratory birds (Salim Ali and Dhillon, 1968; BNHS, 1996) The zoo and phytoplankton, molluscs and nekton (shrimps and fishes) are major source of food for a variety of avifauna. For example the Pelicans feed on fishes, the flamingoes on the detritus as well as micro plankton of the bed. The open and spoon billed storks feed on a variety of molluscs and crustaceans. The zooplankton serves as trophic level-II organisms namely primary consumers (Cushing and Walsh, 1987) which inturn are consumed by secondary and tertiary consumers which include the fishes and the avifauna In recent years a number of aquaculture ponds were located with in the legal limits of sanctuary and were closed due to stay order of Apex court as pond effluents were released, whereas a number of aquaculture ponds were located outside the sanctuary legal limits which release aquaculture pond effluents into fresh water rivers and streams which drain Pulicat lake in Nellore district of Andhra Pradesh

If aquaculture ponds again release effluents, the impact is assessed in the laboratory The World Bank has sponsored a research project through Government of Andhra Pradesh, Forest Department to study the impact of the aquaculture pond effluents. It is opined that the physicochemical and biological properties of Pulicat lake water might affect the avifauna indirectly due to release of effuents. The paper describes the Pulicat lake water parameters and

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results on possible impact of aquaculture pond effluent on hydrobiological factors

Materials and methods

Monthly analysis of Pulicat lake data was carried out near Tada wair The depth form shore to mid lake varies gradually from 0-4 feet and the surface water was collected at different depths while moving on motored Boat (AP Forest Department) between 12 30 to 2 P M. The analytical parameters include dissolved oxygen, carbondioxide, turbidity, total solids, total dissolved solids, total suspended solids, inorganic phosphates, salinity, chlorinity, conductivity, pH and temperature were analysed (A P.H.A., 1976). The population density of zooplankton was estimated by the method recommended by (Lee, 1973; Trivedy and Goel, 1984) Dissolved Oxygen, Carbondioxide was estimated on the spot whereas other experiments were carried in the laboratory at shore.

The above physicochemical parameters were analysed in Pulicat lake water and mixed with different proportions of aquaculture pond effluents Total solids were taken as standard unit (Manoranjitha and Nanda Kumar, 1990) for different proportions of effluent The impact of different proportions of effluents on mortality of Pulicat lake zooplankton and also on prawn seed (Paeneus monodon) was carried out in the laboratory (Finney, 1971).

Results and Discussion

The Table 1 shows the normal physicochemical and hydrobiological parameters of Pulicat lake sanctuary water analysed at different depths of Pulicat lake from April to September (Summer to rainy season) The physicochemical parameters such as pH, BOD, calcium, salinity, chlorinity, total solids, total suspended solids, alkalinity, conductivity, dissolved oxygen, acidity, carbonates, bicarbonates and turbidity were estimated. The hydrobiological parameters namely the biomass of the water weed

TABLE 1

Physico-chemical and hydrobiological parameters of Pulicat lake sanctuary water from April to September, 1999

Sl No.	Parameter (Units)	1 ½ feet* Depth	2 ½-3 feet* Depth	3 ½-4 feet* Depth
1	pH	8 625	8 5	8 5
2	BOD (mg/l)	2 28	2 94	3.55
3.	Free Calcium (mg/l)	309	225	187.5
4	Salinity (g/l)	34.8	35 8	36.11
5	Chlorinity (g/l)	21 13	21 71	22
6.	Total solids (g/l)	56.55	54.3	49.5
7.	Total suspended solids (g/l)	20.75	19.05	12.3
8	Alkalinity (mg/l)	457.5	206.25	131 25
9	Conductivity (siemens/cm)	50.1	20 5	18.65
10.	Dissolved Oxygen (cc/l)	2.76	2 26	2.12
11.	Acidity (mg/l)	0	0	0
12.	Carbonates (mg/l)	25 52	27.03	16 51
13	Bicarbonates (mg/l)	24.41	22.9	24.40
14.	Turbidity (NTU)	6	40	70.5
15.	Free Carbondioxide (mg/l)	48.4	36.3	17 6
16.	Biomass of the aquatic plant (Halophila ovata) (gm/sq foot)	8589.4	1456.7	-
17.	Zooplankton density (100 CFT)	818 5	1541.9	4177.82
18.	Mollu Scan sell biomass (gm/kg of lake bed)	29.80	-	-

Values are mean of 6-observations from April to September' 99.

* The depth from shore to mid lake varies gradually from 0 to 4 feet and the surface water is collected at different points having above depths.

and zooplankton density were estimated The values represent mean range from April to September 1999 These parameters were analysed at different depths. The water samples were collected employing machanised boat (Department of Forest, Government of Andhra Pradesh) at different depths 4-5 Km from shore Analysis of above physicochemical and hydrobiological parameters at different depths are very essential as a few parameters show variation at different depths Hence, the effect of aquaculture pond effluent on the above parameters were studied at different depths also and this procedure would eliminate the possible misinterpretation and erroneous conclusions. For example BOD, calcium, total suspended solids, alkalinity, carbonates and inorganic phosphates show variation in relation to depth (Table 1) The BOD, zooplankton density, turbidity showed an increase with depth On the contrary calcium, total solids, alkalinity, dissolved oxygen, carbonates, free carbondioxide and bicarbonates showed a decrease The Pulicat lake is a brackish water lake of Bay of Bengal. The lake is also drained by Kalingi river and hence shows high salinity. The water samples were collected from shore of lake to sea mouth up to 5 Km Most of the physicochemical parameters were with in the normal limits of the lake water The zooplankton density (Trivedy and Goel, 1984) ranged form 818 to 4177 per 100 CFT of water from 1 ½ to 4 feet depth respectively. The above results show the normal hydrobiological characteristics of Pulicat lake.

Effect of aquaculture pond effluent of Pulicat lake sanctuary water

The chemical characteristics of aquaculture effluents collected from an aquaculture pond are given in Table 5 Table 2 shows the effect of aquaculture farm effluent on Pulicat lake water physicochemical factors, after incubating for 5 days in BOD incubator under laboratory conditions The calcium and carbonates in normal and effluent mixed Pulicat lake water showed a decrease after 5 days The effleunt mixed lake water was found to contain high amounts of carbonates and calcium than normal lake water On the contrary the bicarbonates showed an increase in both normal and effluent mixed lake water after 5 days The inorganic phosphates showed a significant decrease in effluent mixed water and not much change in normal lake water This might be due to consumption of inorganic phosphates by microbes The BOD^5 showed a ten fold increase in the effluent mixed lake water. Organic load of effluent has impact on lake characteristics The above results indicate that aquaculture pond effluents might change normal physicochemical characteristics of Pulicat lake water. This might prove detrimental to organisms also due to change in ambient environmental conditions

Effect of effluent on Pulicat lake zooplankton

The effect of aquaculture farm effluent was studied

TABLE 2

Effect of aquaculture effluent medium on some physicochemical parameters of Pulicat lake water after exposure for 5 days in a BOD incubator at 20 °C

Sl. No	Parameter (Units)	Pulicat lake water		Pulicat lake water + effluent medium*	
		Control (1st day)	Control (5th day)	On first day	On first day
1.	Acidity (mg/l)	0	0	0	0
2	Alkalinity (mg/l)	425	300	375	350
3.	Carbonates (mg/l)	6.005	1.8	12 01	3.0
4.	Bicarbonates (mg/l)	12 205	18.3	12 204	43
5.	Salinity (g/l)	39.51	33.3	40.5	39.13
6.	Chlorinity (g/l)	23 96	20 2	24.57	23.7
7	Indorganic Inorganic phosphates (mg.l)	0 537	0 8	2 15	0
8	Calcium (mg/l)	240	175	240	135
9	BOD (mg/l)		353		551 33

* Effluent total solids concentration = 1080 mg/l

on the zooplankton density of Pulicat lake water with Pulicat lake water as media. The studies were conducted in the AP Forest Field Laboratory located at a place called Waif The effect of aquaculture farm effluent was also studied on Paeneus monodon seed in the laboratory with aquaculture pond water as media The total solid content of the effluent is taken as the standard for expression of effluent concentration (Manoranjitha and Nanda Kumar, 1990). The amount of total solids is estimated in different dilutions of aquaculture farm effluent It is suggested that this type of approach would avoid erroneous results while studying the effects of effluents on zooplankton population, as different aquaculture pond effluents may have different characteristics and choosing the total solid content as the parameter might give a standard universal expression (Manoranjitha and Nanda Kumar, 1990)

The aquaculture farm effluent effect was studied on the total zooplankton collected from different depths and at different exposure periods The Table-3 shows the effect of aquaculture farm effluent on plankton density The plankton collected at 1 ½ feet depth showed 42%–100% mortality for 30–90 min. exposure with 135 mg total solid/25 ml media The Plankton collected from 2 ½-3 feet depth showed 59%–100% mortality and where as plankton collected from 3 ½-4 feet depth showed 36%–100% mortality respectively at different total solid concentration of effluent (Table. 3). Thus, the aquaculture farm

TABLE 3

Impact of aquaculture effluent* on Pulicat lake Zooplankton

		Plankton Collection at		
		1 ½ feet depth % Mortality	2 ½-3 feet depth % Mortality	3 ½-4 feet depth % Mortality
1.	Control	0	0	0
2.	Effluent (540 mg TS/100mL) Exposure for 30 min.	42 31% ±5 1	59 32% ±4 3	36.52% ±2.8
3.	Effluent (540 mg TS/100mL) Exposure for 1 hr	68.27% ±6 2	80 45% ±6.4	66 04% ±5.2
4.	Effluent (540 mg TS/100mL) Exposure For 1 ½ hr	100% ±2.0	100% ±2 0	100% ±2 0

The values are mean of 6-observations

* Effluent collected from aquaculture ponds located outside legal limits of lake sanctuary

TABLE 4

Per cent kill and probit kill for Paeneus monodon with aquaculture effluent*

Sl No.	Total solids of effluent mg/100ml	Time of exposure 2 hr		Time of exposure 3 hr		Time of exposure 4 hr	
		% kill	porbit kill	% kill	Probit kill	% kill	Probit kill
1.	270	0	0	0	0	10	3 72
2.	540	0	0	30	4.48	80	5 84
3.	1080	0	0	50	5.00	100	7.37
4.	2160	10	3.72	100	7.37	100	7.37
5.	4050	100	7.37	100	7.37	100	7.37

No. of animals exposed = 20

* Effluent collected from aquaculture ponds located outside legal limits of lake sanctuary

TABLE 5

Physicochemical analysis of aquaculture pond effluent*

Sl No	Parameters (units)	Aquaculture pond effluent
1	PH	7 5
2	Organic matter (mg/l)	2 19
3	BOD mg/l)	660
4	Calcium (mg/l)	200
5	Salinity (g/l)	31 77
6	Chlorinity (g/l)	19.3
7	Total solids (g/l)	54 4
8	Total suspended solids (g/l)	13.2
9	Total dissolved solids (g/l)	41
10	Alkalinity (mg/l)	750
11.	Conductivity (Siemens/cm)	20 6
12	Bicarbonates (mg/l)	36
13.	Inorganic phosphates (mg/l)	26

* Effluent collected from aquaculture ponds located outside legal limits of lake sanctuary

effluent showed high toxic effects on the plankton. From these results it is opined that the release of aquaculture pond effluent into Pulicat lake sanctuary is hazardous as it causes the mortality of the primary consumers and in this process the secondary and tertiary consumers namely the rare birds which visit the sanctuary would also get affected due to reduction in organisms at lower trophic levels. The flamingos, which visit in large numbers, are both detritus and filter feeders, feed on primary consumers, whereas, the pelicans are tertiary consumers feeding on fishes. Zooplanktons being the trophic level II organisms, the food chain and energy flow might get affected

Laboratory studies

The effect of aquaculture farm effluent at different concentrations were studies on shrimp seed in the laboratory in the control and in the experimental media, which consists of the aquaculture effluent. The per cent kill and probit kill shows a gradual increase with increase in the concentration of effluent *i.e* total solids (Fig 1 & Table. 4) It is suggested that the mortalities might be due to decrease in oxygen level as the organic nutrients (high BOD Table. 2) which consists of oxidisable organic matter might utilise oxygen for its oxidation Table 2 shows an increase in the BOD value in the effluent added Pulicat lake water The effluent might contain pathogenic bacteria and other toxins that might have contributed to the above mortalities

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Survey of Golden Gecko, Habitat Analysis and Conservation in Tirumala Hills

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ABSTRACT

A survey was made in Tirumala Hills of Seshachalam range near Shilathoranam area (Natural Bridge) in the rock boulders. About 24 golden geckos (Calodactylodes aureus) were cited in different rock boulders present within 1-km distance from Shilathoranam area The colour ranged from brilliant yellow to brownish yellow and a few matched with the shade of the rock appearing brown The terminal phalanges of the Golden gecko embryo collected from a matured damaged egg showed expanded phalanges an important anatomical characteristic feature 7 to 9 eggs were found in each cluster It is an endemic and endangered animal and the oldest rock formations are of great ecological value, which provide habitat for Golden gecko This habitat is partly destroyed due to construction of buildings and quarrying Remedial measures are suggested

Key words : Calodactylodes aureus, Expanded phalanges, Golden gecko embryo, Rock boulders and crevices, Habitat destruction

Introduction

Golden gecko (Calodactylodes aureus), a rare species was rediscovered accidentally by Daniel and Bharath Bhushan (1985) after 115 years of its brief and cryptic description by Beddome in 1870. Daniel and Bharath Bhushan (1985) mentioned that it habitat is not located correctly it is like looking for a needle in haystock. No work was reported further after 1985 on the location and its habitat description, clutchsize, excreta, description of embryo to support its characteristic features. Hence a serious attempt was made to identify its habitat, their exact locations in a part of Tirumala Hills. There are reports on various other geckos whose habitat is different. The Andaman Day gecko – phelsuma Andamanese (Whitaker and Whitaker, 1978) is arboreal. The colour ranged from dark brilliant green to brownish black. Eight other species of subgenus Strophurus was reported in Western Australia (How *et al.*,1986) were also mostly arboreal. Our observation shows that Golden geckos (Calodactylodes aureus) are found only in rock crevices. The present investigation reports on the survey made in huge rock boulders in a part of Tirumala Hills which is about 0 5 km from Shilathoranam (Natural Bridge) and also a first report on very distinct characteristics of limbs of Golden gecko embryo and also the clutch size, excreta and their habitat.

Material and Methods

Survey was made in huge rock boulders near Shilathoranam. The visit was made after dawn from 6.30 P.M. to 1. A.M. The geckos were spotted with powerful torchlights on the boulders. A few geckos made vocal sounds, which are distinct and louder than the vocal sounds of house geckos A few geckos were found in the crevices of huge rock boulders When geckos are found in superficial crevices (which are not deep) the geckos can be observed

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closely with lens by focusing light for their characteristic expanded phalanges (Daniel, 1983) and for skiner colour ranging from bright yellow to brownish yellow with dark black round spots of less than 1 mm in diameter. The geckos in the superficial crevices can be observed closely, as their movement is much restricted than the geckos present in the deep and lengthy crevices

The Golden gecko egg which was accidentally found in the crevice and which is in advanced stage of maturity and partly crushed was brought to laboratory and the shell was carefully removed and the animal which was dead was preserved in 10% formaldehyde and was observed in a trinocular microscope (Meiji, Japan) and microphotographs were taken with close lens attachment device.

Results and Discussion

Golden geckos were spotted in mountain rocks as well as isolated big boulders in Tirumala hills near and around Shilathoranam and on the way to Arundhathivanam. The details of spotting of geckos eggs and clutch size, number of excreta points and its habitat is presented in Table 1 The spotting of animals are occasional (Figs 1 and 2) and they are endemic to Seshachalam hills only as they were not found in Kailasa kona rocks which show similar habitat but separated by a distance of 25 km east near Puttur from Tirumala hills.

Animal Description

In two photographs Golden gecko (Figs. 1 and 2) is delineated. The animal colour ranged from yellow to light yellow and dark brown light brown colour matching with the colour and the shade of the rock The terminal phalanges of the animal were found expanded (Fig's 3 to 5). This is the only distinguishing feature to distinguish from other geckos or lizards.

Habitat

In all the locations where the geckos were spotted the following features were found : They are found in the massive boulders and rock crevices; they can be seen in the vertical/horizonatal burrows in the rock, these burrow's temperature was slightly less and more humid than rock areas; spiders in large number (during February), butterflies, dragonflies and a few red ants were found moving on rock boulders.

Eggs and Clutch size

Cluster of eggs were seen near the boulders which contained 7 to 9 eggs. The eggs were found maturing during the months of September and October and also in February and March.

Description of Golden gecko embryo

A matured and broken egg collected near the boulder was shifted to laboratory The embryo was isolated from the egg and observed in a microscope. Front and hind limbs with expanded phalanges, whole embryo, dorsal and ventral side of the expanded phalanges were microphotographed. The microphotgraphs revealed very important and salient feature – The eggs belong to "Golden gecko only" as the expanded phalanges are characteristic feature of Golden gecko (Figs. 3 and 5). The weight of Golden gecko embryo was 672 mg and the egg shell weighed 314 mg.

Excreta

The excreta of Golden gecko was white in colour can be seen near the crevices. The average excreta weight is about 8 3 ± 0.9 mgs.

Habitat destruction and immediate action to be taken and remedial measures

The Golden geckos are distributed only in selected rock boulders near Shilathoranam area. We found to our surprise that a few rock boulders were found blasted either for building or road or parapet wall construction. These boulders might have been used for construction. The geckos were found on the other side of this rock and not on the blasted site facing the road. Basing on this observation it is hypothesized that the entire Tirumala rock formation might be the ideal locations for Golden gecko and these geckos together with its habitat might have been destroyed when roads were laid and buildings were constructed. The existing Golden geckos which are occasionally seen and confined only in certain rock boulders and mountain rocks may be preserved and should not

Fig. 1. Golden gecko in a crevice

Fig. 2. Golden gecko with yellowish brown colour

Fig. 3. Expanded terminal phalanges of Golden gecko embryo

Fig. 4. Ventral side of the expanded terminal phalanges of Golden gecko embryo

Fig. 5. Dorsal side of the expanded terminal phalanges of Golden gecko embryo

be used for construction. A letter to this effect was handed over to Chief Conservator of Forest, Hyderabad during the World Bank sponsored A P. Forestry Project progress monitoring workshop at Hyderabad in February '99 for appropriate action We bring also to the notice that a stone crushing unit is also established near Akashaganga and we request the Tirumala - Tirupati Devasthanam authorities not to use the bigger rocky formation and boulders.

In Shilathoranam area the flood lights are focussed on the Natural Bridge and in these boulders a very small number of golden geckos were seen (Table 1) The TTD authorities can use floodlights only up to 7 P.M This is because the Golden geckos are nocturnal animals and creating a lighted zone would disturb the animals reproduction, physiology, behaviour and movement. We saw the lights are being focussed throughout night and can be restricted upto 7 pm only. Work is in progress to make survey in the entire Seshachalam hill area of Tirumala Hills

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Table 1. Distribution of Golden Gecko in Tirumala Hills and Habitat

Location	No. of Animals and Size (cm)	Eggs	Excreta	Distribution of Habitat and other features
Shilathoranam (Natural bridge in the burrow)	3 No (15-18 cm)	9	9 points (white-colour)	Maturity of eggs in October
	1 No (8-12 cm)			
	2 No (4-8 cm)			
In other boulders · 0 5 km from Natural bridge				
Rock Boulder 1 :	12 No. Spot seen	Egg laid	Innumerable (white colour)	1 Very big boulders boulder 20-25 ft with burrows. Bushes around and ficus tree. 2. Colour ranged from yellow to rock colour background 3. Geckos jump a distance of 2 ft
Rock Boulder 2	3 nos. (pair - ?) facing opposite (8-12 cm)	1	Innumerable	Rockubpulders 10-15 ft partly blasted facing road Geckos seen on other side of the burrow
Rock Boulder 3 . Opposite to Shilathoranam	1 no. inside horizontal burrow	Egg laid	10 points	
	1 no. on the boulder			

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